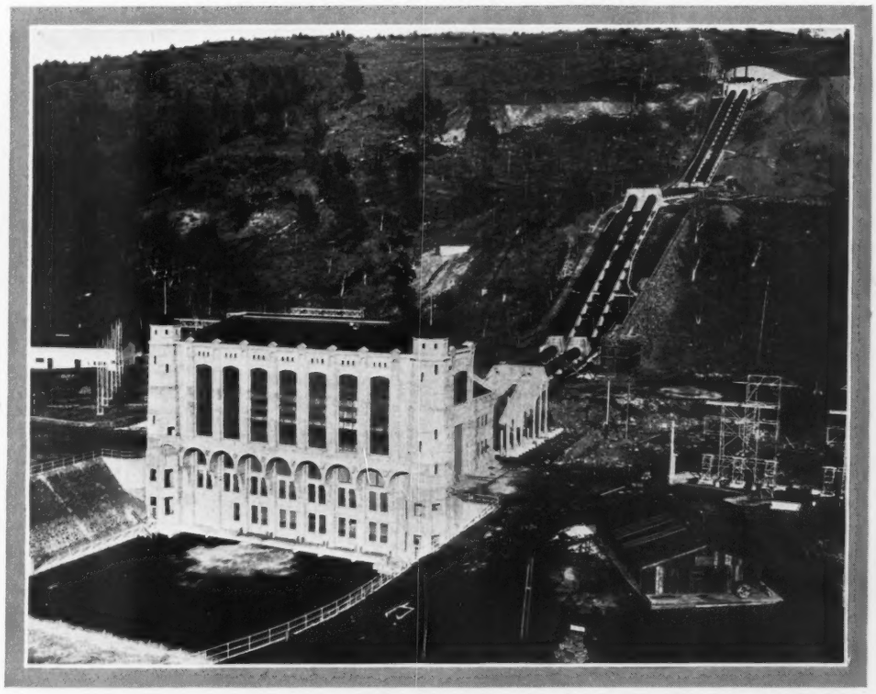
Bureau of Standards
JAN 16 1924

THE TECH ENGINEERING NEWS

MEMBER OF THE ENGINEERING COLLEGE MAGAZINES ASSOCIATED

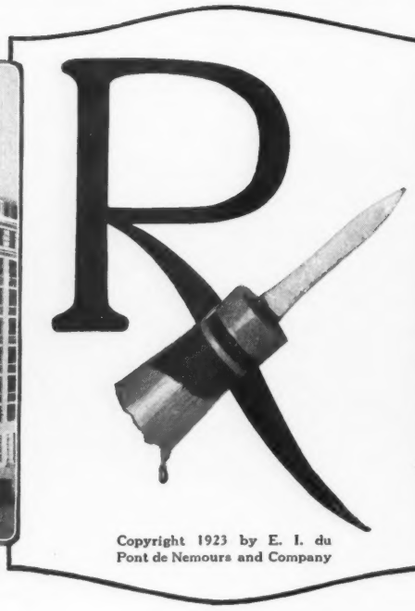
VOL. IV. NO. 7

JANUARY, 1924

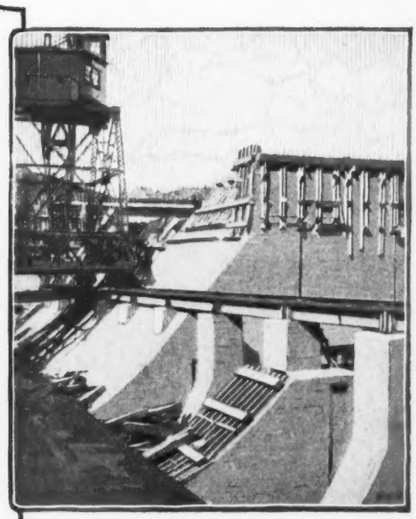


PIT RIVER NO. 1 PLANT OF THE PACIFIC GAS AND ELECTRIC COMPANY
Head from surge chamber (in upper right hand corner) to turbines, 420 feet

MASSACHUSETTS INSTITUTE OF TECHNOLOGY, CAMBRIDGE, MASSACHUSETTS



Copyright 1923 by E. I. du Pont de Nemours and Company



Prescription Paint Service for *Your* Contract

Backed by a thorough knowledge of your field

You have read in preceding advertisements something of the growth and development and functions of du Pont Prescription Paint Service. You have been told how du Pont Chemical Engineers, backed by more than a century's cumulative, broad du Pont Experience, have conducted five years' intensive research into the specific problems of paint protection and perfection.

But the point which we wish clearly to emphasize is *this* — that this research was conducted (and will continue to be conducted) on *actual construction work* in steel, wood and concrete. This was no purely "academic," laboratory experiment.

The essential work of the du Pont laboratory went hand in hand with the tests and reports of du Pont Chemical Engineers *in the engineering field*, observing paint performance on actual plant and structures, working personally with engineers and contractors. Du Pont Prescription Paint Service, then, is vastly *more* than a "Phrase." It means not only *quality control* of paint production, but a specific first-hand, practical knowledge of paint requirements in the engineering field. It enables you to rely upon the du Pont reputation when we say: "THIS is the *correct* paint which we KNOW will serve your purpose best under such-and-such conditions."

Write us describing your requirements and let us "prescribe" the right du Pont paints and varnishes for your work.

Write for the du Pont Manual "Principles and Practices of Upkeep Painting"

A NEW two-hundred-page book covering every conceivable question relating to the selection and application of paints for industrial structures and construction plant, as well as the care and treatment of all woods, masonry and metal surfaces. Address Department B, enclosing your business card.

E. I. du Pont de Nemours & Co., Inc.
35th Street and Gray's Ferry Road, Philadelphia, Pa.

Chicago Varnish Works, 2100 Elston Avenue, Chicago, Ill.
Everett Station No. 49, Boston, Mass.
30 Church Street, New York City

1793 · BORN WITH THE REPUBLIC · 1802
DU PONT
PAINTS AND VARNISHES

The Chicago Temple
Chicago, Illinois
HOLABIRD & ROCHE,
Architects

Drawn by Hugh Ferriss

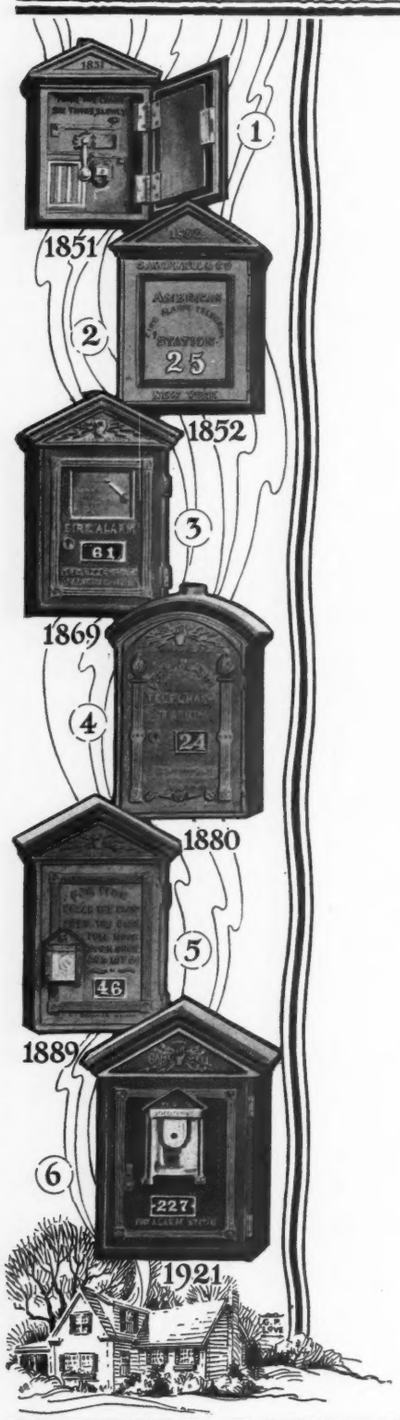
"Building a Picture"

HERE the architects envisioned a picture, saw the modern office building in terms of the great art of the Middle Ages—and the result is a demonstration that the utilitarian structure, the modern office building of commerce may be as picturesque as it is practical. Vision, imagination, courage and practical ingenuity in stylistic adaptation have enabled the architects of this country to astonish the world with their achievements of today and their promise of tomorrow.

Certainly modern invention—modern engineering skill and organization, will prove more than equal to the demands of the architecture of the future.

OTIS ELEVATOR COMPANY
Offices in all Principal Cities of the World

"THE SIX AGES OF THE FIRE ALARM BOX" —



THE fundamental principle of the fire alarm telegraph — opening and closing a telegraph circuit — has remained unchanged since the first Boston box, but the box itself has been completely revolutionized.

1. *Original Boston Box — 1851.* Practically nothing but a telegraph key opened and closed by the manual operation of a notched wheel. Enclosed in a wooden case.

2. *Box Driven by Clock Work — 1852.* This insured a uniform rate of speed in the transmission of the signal mechanism enclosed in cast iron cases to protect it against injury and the elements.

3. *Box with Non-interfering Pull — 1869.* It was found that after the hook had been pulled and the movement started that occasionally the starting lever would be again pulled which would result in a mutilated signal. The development of the non-interfering pull prevented this.

4. *Non-interfering Box — 1880.* Up to this time if two boxes were operated on the same circuit at the same time there was a possibility of confused signals and a danger that one or both of the alarms might be lost. The non-interfering box prevented jumbled signals, but there was a possibility that one of the signals would not be received.

5. *Successive Box — 1889.* This box went a step further than the non-interfering box. When two boxes were pulled on the same circuit there would be no interference and both signals would be received.

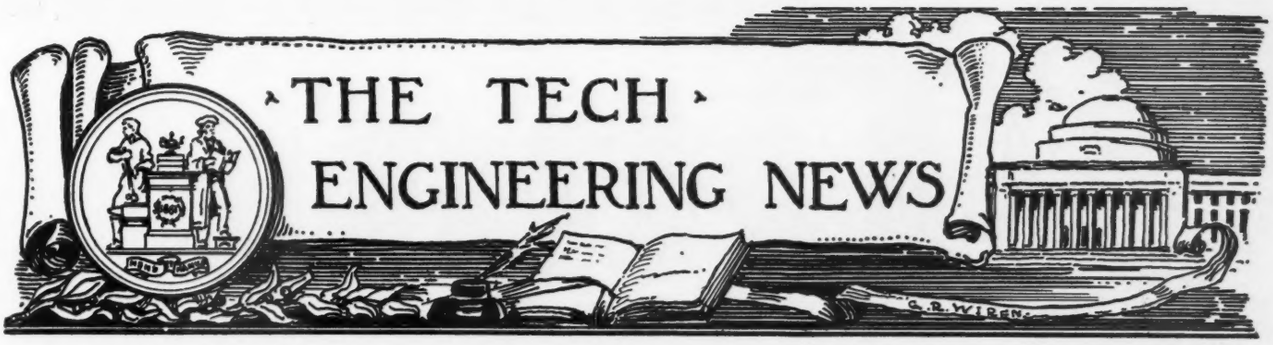
6. *Peerless Box — Porcelain Steel Cases — Quick Action Door — 1921.* Porcelain Steel inner cases give double the protection against lightning and high voltages. Improved method of operating the box cuts down the time consumed in sending signal.

In 1855, four years after the original installation in Boston, John N. Gamewell came into the fire alarm business. Step by step since then the box has developed and we have developed with it. Improvements have been steady but not radical. The lives and property at stake forbid untried experiments. When Gamewell apparatus is specified you can be certain that the principle has been found sound and that the design has been tested by actual field experience.

THE GAMEWELL COMPANY

NEWTON UPPER FALLS, MASS.

FIRE AND POLICE SIGNALING SYSTEMS



Volume IV | CAMBRIDGE, MASS., JANUARY, 1924 | Number 7

Copyright 1923 by The Tech Engineering News

Entered as second class matter, June 1, 1920, at the Post Office at Boston, Mass., under the Act of March 3, 1879.
Acceptance for mailing at special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized November 3, 1920.
Published monthly throughout the school year by the undergraduates of the Massachusetts Institute of Technology for the purpose of disseminating news of scientific and industrial interest and of promoting closer coöperation between Alumni and undergraduates.

THE MANAGING BOARD

HILLIS R. CLARK, *Editor*
DOUGLAS F. ELLIOTT, *General Manager*
HAROLD G. DONOVAN, *Business Manager*
WENDELL F. BURBANK, *Managing Editor*
WILLIAM H. MACCALLUM, Jr., *Publicity Manager*
MORROUGH P. O'BRIEN, *Personnel Manager*
CHARLES L. PETZE, Jr., *Circulation Manager*
BERNARD E. GROENEWOLD, *Advertising Manager*

EDITORIAL DEPARTMENT

THE EDITORIAL BOARD

R. W. STEWART, Associate Editor
R. R. SMITH, Associate Editor
E. D. MURPHY, News Editor
F. P. ROMANOFF, Assistant Managing Editor

STAFF

E. L. PERRY
H. HUMPHREY
J. Y. HOUGHTON
R. H. MASER

BUSINESS DEPARTMENT

THE BUSINESS BOARD

C. S. STODTER, Business Assistant
S. EMERSON, Assistant Business Manager
W. L. NYE, Assistant Circulation Manager
C. A. HARRISON, Assistant Advertising Manager

STAFF

J. C. CULBERTSON
J. L. CASSIDY
E. E. KUSSMAUL
R. F. TERRILL
D. H. McCULLOCH
S. SAGERMASTER
J. B. WRIGHT
E. A. CHURCH
F. G. CUNNINGHAM
C. P. McHUGH

PUBLICITY DEPARTMENT

J. L. OSTBORG
J. R. KIMBERLY

THE ENGINEERING COLLEGE MAGAZINES ASSOCIATED
Chairman Edwin Kurtz, Ames, Iowa

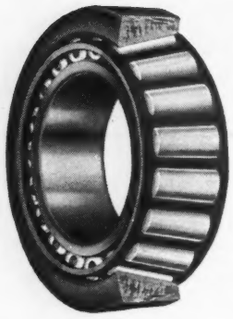
The Transit
Iowa Engineer
Colorado Engineer
Nebraska Blue Print
Towne Scientific Journal
Sibley Journal of Engineering
Rose Technic
Michigan Technic
Ohio State Engineer
Minnesota Techno-Log
The Tech Engineering News
University of Virginia Journal of Engineering
Wisconsin Engineer
Penn State Engineer
Illinois Technograph
Cornell Civil Engineer
Kansas State Engineer
Princeton E. A. News Letter

Subscription, per year, $1.75. (To Technology Students $1.50) Single Copy $.25
Address all communications to The Tech Engineering News, Walker Memorial, Cambridge 39, Massachusetts. Telephone, University 6364
Advertising rates upon application.

TABLE OF CONTENTS

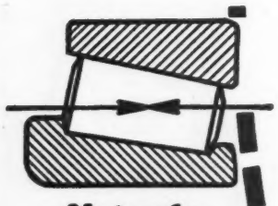
	Page
RELINING A TUNNEL WITHOUT INTERRUPTING TRAFFIC. By Walter B. Snow, '82 and Staff	253
HISTORY OF THE SOCIETY OF ARTS. By Professor H. M. Goodwin, '90	254
THE HYDRO-ELECTRIC POWER PLANTS OF CALIFORNIA. By Charles F. Gross,'16	256
THE MERCERIZATION OF COTTON. By William S. Rowley	257
CONTRACTION AND SHRINKAGE OF NON-FERROUS ALLOYS. By Robert J. Anderson	258
PUTTING RADIO TO WORK. By Captain H. W. Webbe	259
JAMES PHILLIPS BARNES. By E. F. Kelley	260
THE ELECTRICAL ENGINEER ON SHIPBOARD. By G. A. Pierce	261
THE ALDRED LECTURES.	262

Dual

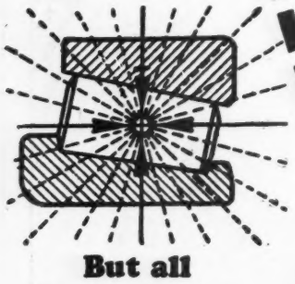


TIMKEN
Tapered
ROLLER BEARINGS

Not only Radial Loads



Not only Thrust Loads



But all Combinations of both

Rarely is an anti-friction bearing so favored as to need nothing more than the ability to carry pure radial (straight up-and-down) loads.

In an automobile, if the car tilts even slightly sidewise, or swings corners, there is side-thrust added to the normal up-and-down (radial) loads. In a machine, even when there is no other thrust, merely the running of a belt on a crown pulley imposes thrust.

As a matter of fact, an anti-friction bearing cannot pretend to be all-capable unless it carries the endless varieties of *combined* thrust and radial loads, present in nearly all bearing mountings.

Timken Tapered Roller Bearings do inherently provide this essential *Dual Duty* capacity, and the same principle gives Timkens their famous quality of adjustability for the wear that *must* follow motion.

The engineer of today finds no greater aids to the more efficient design and operation of machinery than Timken Tapered Roller Bearings. As your experience grows Timken ability may give you good reason to concur in Timken ascendency in all mechanical engineering fields.

The Timken Roller Bearing Co
CANTON, OHIO

Duty

©1923, By The T R B Co, Canton, O

THE TECH ENGINEERING NEWS

THE PROFESSIONAL JOURNAL OF THE ALUMNI AND UNDERGRADUATES OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

VOLUME IV JANUARY, 1924 NUMBER 7

RELINING A TUNNEL WITHOUT INTERRUPTING TRAFFIC

By WALTER B. SNOW,'82, AND STAFF
Boston, Massachusetts

THERE was no question that the Coulter Tunnel, a hundred odd miles northeast of Pittsburgh, on the Pittsburgh and Shawmut Railroad, was in a bad way. Locomotive gases, ground water and other conditions had caused serious decay in the timbering and something was needed badly to safeguard the tunnel against possible failure. Preliminary investigation indicated that the best reinforcement would be furnished by the construction of an interior concrete lining.

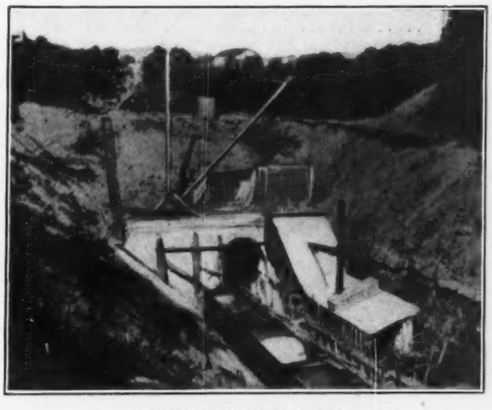
In itself this was no easy task and to make conditions even more difficult the lining had to be placed without interfering with the regular traffic schedule. Ten or a dozen long coal trains and several passenger trains roared through every day, giving the Coulter Tunnel little in the way of rest.

But "Resourcefulness" is the middle name of an engineer, and with the help of a Ransome pneumatic mixer installed alongside the track just outside the portal, Westinghouse, Church, Kerr (now Dwight P. Robinson) successfully met the conditions and lined the tunnel at the rate of about one hundred twenty feet a week.

The first step was to sheet the inner faces of the timbers with seven-eighths-inch tongue and groove boards covered on the inside with three-ply paper and tar waterproofing. To permit free drainage of any water leaking through the old wooden lining the spaces between the bents and the inner and outer sheeting were filled solid with gravel. A drain conducted this water to the portals.

When this draining and waterproofing construction was completed, movable forms in thirty-foot sections were set up, leaving an average space of two feet between them and the waterproofed lagging, the forward bent being closed by wooden bulkheads. This space was then concreted by the Ransome pneumatic placing process.

The horseshoe cross section of the tunnel was about twenty feet, six inches wide by twenty-six feet high, while the concreted portal had a width of sixteen feet, six inches and was twenty-four feet high. In order to place the preliminary waterproofing and drainage on the timbering, a scaffold car was installed, enabling the men to work at different heights. This was made by building a twelve-foot tower on the floor of a flat car. Six vertical bents were used, providing center spaces in which transverse horizontal beams were placed and arranged so that they could be moved in to permit the car to enter the narrow portal. Once inside the tunnel these beams carrying the working platforms on their outer ends were extended to the full width of the tunnel. The scaffold car was also used to remove a considerable quantity of defective timber, as well as for its original purpose of assisting in the waterproofing.



THE COULTER TUNNEL

As can be seen from the accompanying photograph, the Coulter Tunnel presented unusual difficulties in the matter of storage and working space. The problem was finally solved by building bins for the aggregate directly over the tunnel portal itself. These bins had an aggregate capacity of eighty cubic yards and were filled from cars of sand, gravel and cement which were run in on a three hundred-foot siding built for the purpose. The cars were unloaded by a clam shell bucket operated by a derrick that delivered directly to the storage bins. From there the aggregate was discharged by gravity to the Ransome Pneumatic mixer. The cement was stored in two twenty-by-one-hundred-foot houses about a mile from the tunnel entrance. The two work trains that were maintained by the contractor handled the delivery as needed on the job.

In order to provide concrete water it was necessary to go to a spring nearly a mile away on the top of a hill one hundred sixty feet above the tunnel. This was impounded in a six-by-eight-foot concrete cistern from which it was delivered through a two-inch pipe carried below the first line to the sixteen thousand-gallon reservoir near the mixer which was formed by the construction of a concrete dam. The camp was supplied with water from cisterns and the power house was by pumping from a ten-by-ten-foot concrete pump built in a creek a half mile away.

For the concreting, four Blaw collapsible steel forms mounted on towers traveling on special broad-gauge tracks were installed, permitting the train service to pass through them without interruption. The surface of the forms was covered with steel plates up to the springing line and above that with detachable wooden lining. The forms were collapsed by the removal of a key at the crown and by an ingenious device on the axle of the truck wheel that retracted the side walls.

All concrete was mixed in a Ransome pneumatic mixer installed alongside

(*Continued on page 288*)

HISTORY OF THE SOCIETY OF ARTS

By PROFESSOR H. M. GOODWIN, '90
Professor of Physics and Electrochemistry, Massachusetts Institute of Technology

By an act passed by the General Court on April 10, 1861, The Massachusetts Institute of Technology was incorporated "for the purpose of maintaining a Society of Arts, a Museum of Arts, and a School of Industrial Science, and aiding generally by suitable means the development, advancement, and practical application of Science in connection with Arts, Agriculture, Manufacture and Commerce."

Today the Massachusetts Institute of Technology has come to connote in the minds of the public the third of the above objects only, that is, the School of Industrial Science. The Museum of Arts as conceived by the founder of the Institute has never been established. The Society of Arts, on the other hand, although it has not attained the prominence and importance of the School of Industrial Science, has nevertheless, played a long and honorable rôle in connection with the development of the school, particularly in the early days of its trials and tribulations. It is probably not known to many at the present time that during the first three years after incorporation, the Institute of Technology, so far as its public activities were concerned, functioned solely as "The Society of Arts."

The first public meeting of the Massachusetts Institute of Technology as a scientific institution was held on December 17, 1862 in No. 3, Mercantile Building on Summer Street. President Rogers presided, and in his opening address stated the object of the Society as follows:

"In its meeting as a Society of Arts, twice in every month, the Institute will have in view, as its leading object, the promotion of the practical arts and sciences through the medium of written and oral reports and communications and the exhibition of models, materials, products and other objects relating to them as well as through explanations, descriptions and criticisms to which they may give rise. Aiming to secure a free communication and interchange of valuable thoughts on all matters relating to the industrial sciences and arts, it will desire to guide as well as to stimulate research and invention, and, while marshalling in emulous and coöperative labor the cultivators of the applied sciences and the arts among us, will offer them an appropriate theatre for the exhibition of their researches or their handiwork and will, it is hoped, after a time, furnish also a suitable medium of publication in the journal which forms one of the features of our general plan." "The present accommodations are amply sufficient for our immediate purposes as a Society of Arts, and nothing is needed for the success of this branch of the Institute but that members and friends shall contribute from their stores of knowledge and invention whatever may give value and interest to the meetings in this hall. From the mill, the farm, the machine shop, the laboratory, the shipyard, from the desk of the engineer and architect, the chair of science, the workman's bench, the merchant's counting room, and all the other scenes where educated industry is at work, we may claim and expect the aid of vigorous thought and coöperative labor; and knowing how mighty is the momentum of the industrial intelligence around us, we can scarcely doubt that the efforts of this branch of the Institute will prove of substantial public interest and advantage. . . . "

It was not until three years later that the School of Industrial Science first opened its doors to the class of 1868. During this time and in the years following, the Society of Arts met twice a month, and in the archives of the Institute is to be found a complete record of these meetings, many of which were fully reported in the daily papers as indicated by numerous clippings inserted in the records. The papers presented were on the most diverse topics. At the first meeting R. B. Forbes presented two papers on "Subaqueous Gun Firing" and "A Combination of Wood and Iron in Ship Building"; E. S. Ritchie, a paper on "Improvements in Boat and Ship Compasses," illustrated by an exhibit of his own instruments; and S. R. Ruggles exhibited "a boat model with a stern wheel, the floats of which instead of being straight as in the common paddle wheel are formed of warped surfaces meeting at an angle which points in the direction of the rotation." In May, 1876, Mr. Alexander Graham Bell explained before the Society his apparatus illustrating "Telephony or the Telegraphing of Musical Sounds," this being, it is believed, the first public demonstration of the telephone. This was followed the next year by other lectures on the telephone by Mr. Bell and Professor Dolbear. The records show that other important discoveries were brought before the Society in these early years. To mention only a few, Professor Langley described his famous bolometric investigations on the distribution of solar energy in the spectrum; Prof. Elihu Thomson explained the Thomson-Houston system of electric lights, and Professor Cross showed the Crooke's tube phenomena soon after their discovery.

When General Walker assumed the office of president of the Institute, President Rogers formally introduced him to the Boston public at a meeting of the Society of Arts held November 10, 1881. In his address President Rogers summed up the activities of the Society during the preceding nineteen years in the following words:

"It is now very nearly nineteen

THE TECHNOLOGY SERIES

Last year THE TECH ENGINEERING NEWS published a series of articles on the buildings, laboratories and business administration of the New Technology. This series met with such widespread approval among our readers that we are continuing the idea this year. Our new series will be of a slightly different character, dealing with the great personalities and the more human side of the Institute. As our space limits us to only a bare outline of the subject, it is hoped that the new series will serve as an inspiration to further reading along this line. The topics which the series will cover are as follows:

THE FOUNDERS OF THE INSTITUTE ..... October
Prof. H. W. Tyler, Head of the Department of Mathematics.

FRANCIS AMASA WALKER ..... November
J. P. Munroe, Secretary of the Corporation, M. I. T.

RICHARD COCKBURN MACLAURIN ..... December
Harold Eric Kebbon, Architect.

A HISTORY OF THE SOCIETY OF ARTS ..... January
Prof. H. M. Goodwin, Department of Physics.

A HISTORY OF THE DEPARTMENT OF ARCHITECTURE..... February
Prof. William Emerson, Head of the Department of Architecture.

A HISTORY OF THE DEAN'S OFFICE..... March
Author to be announced later.

RELATION OF INSTRUCTOR TO STUDENT AT TECHNOLOGY ..... April
Prof. L. M. Passano, Department of Mathematics.

GREAT GATHERINGS AT TECHNOLOGY..... May
Author to be announced later.

years since the Society of Arts held its first meeting in this city in humble rooms in Mercantile Hall on Summer Street. It was then the Institute of Technology. As yet there were no means for establishing a school such as has now attained success and importance. There were no funds, and there were comparatively few friends of the enterprise which had just been set on foot, and which had, to a certain extent, been sanctioned by the action of the Legislature. Only one year after the charter of incorporation had been granted, in the midst of the thunders of the Civil War, the Society of Arts, the very first fruits of the Institute of Technology, was established in this city. Without capital, with only such brains as we might claim to possess, some half-dozen citizens of Boston assembled together to constitute the Institute of Technology in its active form as then presented, and the only form of activity that it could assume was simply to collect persons together every week or two and hold lectures or meetings somewhat after the fashion of those that are now held by this Society; and in the records of the Society at that time always the statement was made "Meeting of the Institute of Technology as the Society of Arts." But it was not until three years after this in the month of February, that the School of Technology, which is the transcending and most obviously important element of the Institute of Technology, was established, in the same neighborhood in Boston, to be transferred, in the succeeding year, into the ample accommodations and arrangements of this building.

"Such then, was the history of the Society of Arts in its early stage; and although it has not prospered as many societies have prospered, yet it has steadily performed good work, as is evinced by the character of the records which it can exhibit. It might have prospered more rapidly and have attained to what might have been called magnificent proportions, relatively speaking, had it not abstained with conscientious care from all exhibitions which might have the taint of commercial recommendation. It has carefully and sedulously abstained from these, and hence today it maintains its pure reputation as an institution for the promotion of mechanical science and the useful arts without any reference whatsoever to the mercantile interest of any of the individuals representing the Corporation. This is something to be said to its credit, because those who have been with me in this matter well know how many have been the inducements, how frequent have been the temptations and seductions presented to deviate from this course of pure scientific and educational rectitude, and in no case has such a deviation, one hair's-breadth, been ever permitted. Now, gentlemen, we have attained a point in the growth of the Institute which seems to demand a corresponding expansion in this department of the Institute. It cannot be severed from the Institute of Technology under any circumstances. It is properly growing, and I trust its future growth will justify the hopes that have been entertained in the early part of its history."

General Walker, in taking the chair, then paid the following tribute to the retiring president:

"In assuming this chair I am deeply sensible of the honor of presiding over the Society of Arts, as indeed, of the privilege of attending its meetings and listening to its proceedings. In studying the published records of the Society during the last two years I have been greatly impressed as well as gratified at the very wide range of subjects which has been covered by the papers presented here and by the discussions upon them. Academies and societies of arts and sciences are of two kinds: those for repose and those for work, and the catalogue of papers which have been presented to this Society shows that it belongs to the latter class. I cannot, I do not even presume to hope, that I can fill President Rogers' place here. Greatly as he must be missed in every department of the Institute, it is here most of all that his loss must be felt. A recognized master in every department of physical science, and gifted with rare eloquence and powers of statement, it has been for many years his easy and pleasant task to give an appropriate and agreeable introduction to every paper offered to the Society, to join in the discussion of any topic, however abstruse, and to sum up the facts and arguments offered, in a thoroughly judicial spirit, and with the full advantage of the ripe results of modern researches. For myself, a student, only in the department of political and social science, that office is denied. I cannot presume even to express an opinion concerning the majority of the topics which are likely to be brought forward for your consideration. I know, therefore, that the Society will feel painfully and will long continue to feel painfully, the loss of a president who could both preside and lead — a man fitted to instruct anybody, however learned, whose suggestions and briefest comments have always been an inspiration in the pursuit and discovery of truth, and who, as president of the National Academy, today illustrates and honors American science as no other man could. . . ."

The following June Professor Rogers died in the act of addressing the graduating class from the platform in Huntington Hall. The first meeting of the Society of Arts held the following fall, on October 12, 1882, was a memorial meeting, at which President Walker, Prof. William P. Atkinson, Mr. James P. Tolman, Prof. John D. Runkle, Prof. C. R. Cross and Major J. Hotchkiss paid glowing tributes to their past president. General Walker in opening his address said:

"We have tonight assembled together to commemorate the life and scientific work of Prof. William B. Rogers, who a little less than a year ago in this hall relinquished the position of president of the Society of Arts, which he had so long held. The relation of the Society to its retiring president was a peculiar one, so peculiar as to be almost unique. It was not that he was the Society's first president, that he was its founder, that to his conception the Society owed its existence; there was more than this in the parting between Professor Rogers and the Society of Arts. From the first he had been in a high sense its life and soul. Mind and heart he had been wholly devoted to its interests. He had watched over its growth, had labored for its advancement in scope and influence, and had devoted to it all the energies of one of the rarest and richest minds which this country or the larger and older world of science has ever known. . . . And when the paper was read and the discussion closed, shall we ever forget what a glow, as of poesy and romance, his fervid eloquence — eloquence such as no man since Chalmers has possessed — threw over and around even the most dull and difficult among the subjects of scientific investigation! For to Professor Rogers the truth was always beautiful, and the most solid and substantial structure of scientific principle stood in his view against an evening sky radiant with a light which no brush of painter could portray."

These words express how much the success of the Society of Arts was due to Professor Rogers' personality. No president since his time has been able to maintain that enthusiasm in the Society which he was able to arouse. There can be no doubt that the Society of Arts under President Rogers' leadership did much to aid indirectly the School of Industrial Science, for the Society numbered among its members many of the leading citizens of Boston whose interest and financial support were essential to the Institute's development.

The early proceedings of the Society of Arts from 1862 to 1878 are to be found only in the archives of the Institute. From 1879 to 1891 the "Abstracts of the Proceedings of the

(*Continued on page 288*)

THE HYDRO-ELECTRIC POWER PLANTS OF CALIFORNIA

By CHARLES F. GROSS, '16
Assistant Professor of Marine Engineering and Naval Architecture, University of California, Berkeley, California

IT is questionable whether such an extensive inspection trip has ever been made of as large a number of hydro-electric plants as was done during the month of May, 1923. The party consisted of the following: Prof. Blake R. Vanleer of the University of California, Purdue '15; Mr. Albert J. R. Houston, University of California '20, Massachusetts Institute of Technology, II, '21; Mr. John M. Goodnow, Massachusetts Institute of Technology, II, '21 and the author, Massachusetts Institute of Technology, '16, XIII. The object of the trip was to see the handicaps which were being overcome in construction, operating, conditions existing at the various plants, the efficiency of the operating personnel and finally, to gain first-hand information as to how the hydro-electric resources in the State were being developed. When it is considered that we covered approximately two thousand eight hundred miles from the time we left Berkeley the first of May to our return the latter part of the month, bringing us in contact with twenty-eight large plants, one-quarter of the State's total hydro-electric plants, it may be seen that we were moving all the time.

The general outline of our travels was to go directly south to Los Angeles by the coast highway. After inspecting the plants in the vicinity of Los Angeles we started to work north in the San Joaquin valley, inspecting those plants in the Sierra mountains, terminating at Pit River No. 1 plant of the Pacific Gas and Electric Company in the extreme northern part of the State. Our mode of conveyance was a five-passenger 1923 Maxwell car. We carried our sleeping bags but other equipment was at a minimum. This meant that we ate most of our meals at the construction camps or small towns en route, thereby saving much time in preparing meals. In such a trip there are certain facts which must be borne in mind. Most of the plants were not on the main highways but far up river canyons, off the beaten road. This necessitated us at times leaving the main road and directing our course to a gap in a mountain, up which we knew was located the power plant which we sought. Sometimes our course lay over rough and rugged country having no wheel impressions of a former auto to guide us. Furthermore, as this was the latter part of spring, most of the creeks were high from melting snow, and in places the proverbial axle-deep mud roads were encountered and our engine was at times stalled in the creeks where the running board was awash.

A brief outline of the companies visited and the districts in which they operate is as follows:

1. Plants of the City of Los Angeles. Located in the southern part of the State.

2. Southern California Edison Company. The center of their distribution load is Los Angeles, located two hundred forty miles from their plants on Big Creek, San Joaquin and Kern Rivers.

3. San Joaquin Light and Power Company. The distribution center is at Fresno and Bakersfield, in the heart of the wealthiest agricultural region of the west, with their plants located on the Kern, San Joaquin and King's Rivers.

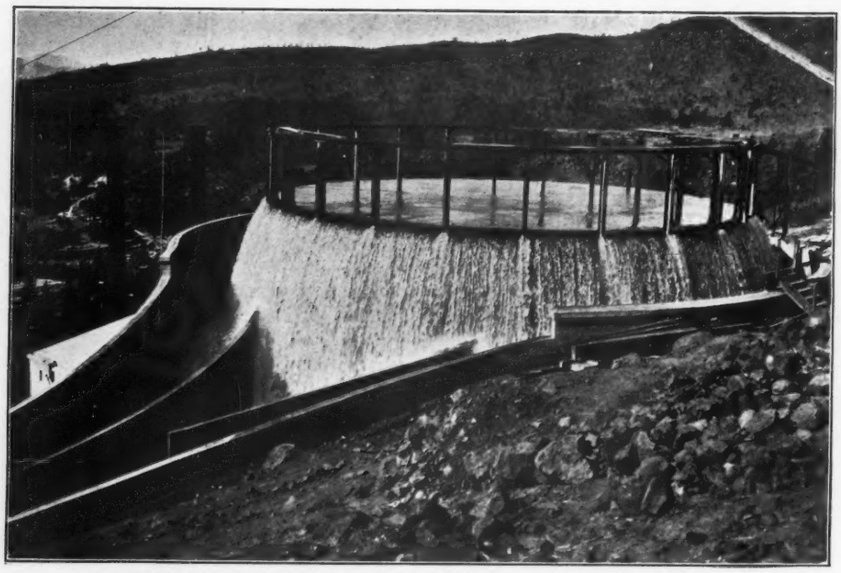
4. Turlock and Modesto Irrigation District. Of significance is the Don Pedro Dam with a power plant at the base.

5. San Francisco's water supply and power plants. Of importance is the O'Shaughnessy Dam, located one hundred sixty-eight miles from San Francisco with reservoirs, tunnels, dams and power plants distributed along the one hundred sixty-eight miles.

6. Pacific Gas and Electric Company. Their plants are distributed in the Sierras from those due east of San Francisco to those on the Pit River, two hundred fifty miles north of San Francisco.

Water power development in the west, in the main, has not followed the popular conception of such enterprise. The general idea of a power project involves the harnessing of a waterfall, such as Niagara, or of lesser magnitude, whereas the typical western development usually involves no waterfall of any size. The power project is located in a mountain canyon where either a reliable minimum flow of the stream may be found the year round, or else storage is developed, above the point of such diversion. Such a power site requires no waterfalls, merely rapids in a stream. The water is diverted by a ditch, flume or tunnel and conducted through or around the mountain side at a less grade than that of the stream. When this is continued for many miles it is evident that a difference in level will occur between the water in the ditch and that in the natural run of the stream. As a consequence, at the end of from two to fifteen miles of ditch, flume or tunnel, we have a drop of from one hundred to two thousand five hundred feet. Such are the artificially created waterfalls as compared to the natural falls.

The plants visited which were owned and operated by the City of Los Angeles were those in the San Francisquito Canyon, about forty miles from Los Angeles. These are designated as



SURGE CHAMBER SPILLING WATER, PIT RIVER NO. 1

(Continued on page 290)

THE MERCERIZATION OF COTTON

By WILLIAM S. ROWLEY
Service Engineer, H. W. Butterworth & Sons, Philadelphia, Pennsylvania

THERE is possibly no branch of the textile industry that has made as great progress during the past twenty-eight years as mercerization. Not that the treatment of cotton with caustic soda, sulphuric acid, nitric acid, zinc chloride solution and similar reagents was first practiced only twenty-eight years ago, for it was in 1844 that John Mercer, a Lancashire calico printer, announced his discovery of what was afterwards mercerizing. In Mercer's time the process was called "sodaizing" or "fulling."

However, from 1844 until 1895 there was little commercial use made of Mercer's discovery. This was due to the cost of reagents and more largely the loss in fabric area due to shrinking which was and still is about thirty per cent.

Mercer in his experiments was probably seeking only one of the three results that he attained, that is, he wanted to shrink cotton and plant fibre, before this thought wholly unshrinkable. However, he found that the fibres in the fabric in shrinking became fully twice as strong, also that it had developed a greatly increased affinity for coloring matter. Following his experiments with fabric in the piece, Mercer experimented with cotton yarns and found that the same result was achieved as when the fabric was treated.

It was not until 1889 that H. A. Lowe took out a patent for mercerizing fabric under tension. This causes the permanent gloss, now an identifying mark of mercerization.

For some reason or other Lowe did not follow up his invention with production. The patent was allowed to lapse until 1895 when two men, Thomas and Prevost, again took out a patent on the process. Through some freak of fortune the publicity given an action against Thomas and Prevost to annul the patent was responsible for creating a demand for the high gloss fabric. The patent was annulled on the ground that it had been anticipated.

In his experiments Lowe used an apparatus similar to the household curtain stretcher. Cotton goods in piece form were stretched on this, being held under tension on all edges. The caustic soda solution was then applied. The fabric almost immediately attempted to shrink; being unable to do so beyond a limited degree, the fibres started twisting. The inside of the fibre was thus brought out, the cells reflecting and deflecting light. The fabric, then washed under tension, retained its brilliant lustre.

Early mercerizing was confined to yarn in skein form, piece goods mercerizing coming some years afterwards. The skeins were held on arms eighteen inches apart; a hank of eighty-four yards was put on two of these and dipped into the solution by hand.

This method of handling yarn to be mercerized soon gave way to a machine with a series of arms. These were all dipped at one time. This machine enabled the first saving of time labor in the process of mercerizing. The arms on this machine were adaptable to stress required.

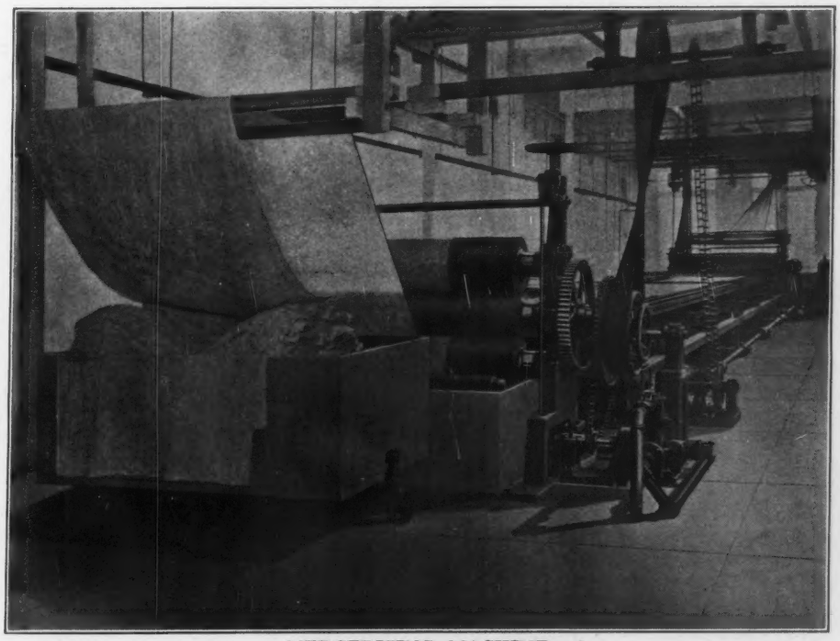
However, like spinning, carding, dyeing and weaving, the process of mercerizing has gone through a long, tedious improvement up to the present-day warp-mercerizing in huge machines often 150 feet long by 10 feet and capable of mercerizing 24 warps of 378 threads and 6,000 yards long in eight hours. Recently, however, we have been constructing mercerizing ranges capable of handling three or four times this amount of work. In warp mercerizing the warp is started through in mill condition, that is, on warp balls.

The number of warps in the operation is determined by the count of the yarn. First, the yarn is boiled, then cooled, "causticized," washed, neutralized, rewashed, squeezed and finally dried over cylinders. Between each of these operations the yarn is passed through squeeze rolls. At the end of each mercerizing range is a compensator which determines the stress on each strand of the warp. After going over the drying cylinders the warp is plaited down into boxes ready for the bleachery. In some cases, however, it goes directly to the knitter.

Often the question has arisen, "Just which is the best cotton for yarn mercerizing?" We would say that to get the best results clean, long-staple A-1 cotton should be used. In the picking, also the spinning, the cotton should have been carefully handled and threads smoothed out evenly. Often what has been called "poor mercerizing" is actually poor cotton — short-staple — slazey, which has been roughed up and has many ends or "whiskers."

All water should be absolutely clean. As a matter of fact it is always a safe plan to have the water analyzed, for in the process the warp is boiled many times and anything wrong with the water often leads to the warp taking the caustic unevenly. In view of the fact that mercerizing has an effect on the dyeing of yarn or fabric, uneven mercerizing is always sure to result in uneven dyeing.

(*Continued on page 294*)



MERCERIZING MACHINE

The illustration shows complete range of machines, consisting of caustic padding machine, tentering machine of heavy construction equipped with automatic clamp chain, and compartment washing machine. The range can be adjusted to suit any width desired.

CONTRACTION AND SHRINKAGE OF NON-FERROUS ALLOYS

By ROBERT J. ANDERSON
Metallurgist, United States Bureau of Mines, Washington, D. C.

WHILE the contraction of alloys is only one of the factors that bear on cracks in castings, as well as on the casting qualities of any alloy, still it is important; and comparative figures as to the contraction of various alloys will serve as a guide to their casting qualities and cracking tendency. For example, some preliminary work shows that the contraction of aluminum alloys is a cogent factor in determining their cracking tendency in the production of both sand castings and die castings. Thus, other conditions being the same, one alloy having a relatively larger linear contraction was found to crack more readily on casting than another alloy having smaller contraction.

When a metal or alloy is cooled from the liquid state at any temperature to the solid state at any temperature its diminution in volume is the algebraic sum of three separate contractions, namely, (1) in cooling from any temperature in the liquid state to the freezing point; (2) in passing from the liquid state at the freezing point to the solid state at the melting point; and (3) in cooling from the solid state at the melting point to any lower temperature. These three contractions in volume have been termed respectively, (1) the liquid shrinkage, (2) the solidification shrinkage, and (3) the solid shrinkage. Reliable data as to the contraction of the various metals on passing from the liquid state to the solid state are scant, but on the basis that practically every well-defined property of the elements is a function of their symbol weights, it may be deduced that the contraction in volume of the metals is a periodic function of their atomic weights.

The liquid shrinkage may be considered to be the amount of contraction in volume of a metal or alloy in the liquid state on cooling from any temperature in the liquid state to the freezing point. The greater the temperature interval through which the metal cools the greater the liquid shrinkage. This explains why the weight of metal that can be poured into a mold at a higher temperature is less than at a lower temperature.

The solidification shrinkage may be defined as the contraction in volume of a metal or alloy on passing from the liquid state at the freezing point to the solid state at the melting point. Where an alloy solidifies over a freezing range, the solidification shrinkage is the contraction in volume which occurs from the beginning to the end of freezing. The actual amount of the solidification shrinkage varies considerably for different metals and alloys, and it may be markedly affected by the presence of impurities. So far as is known, bismuth is the only metal that expands on solidification, but a number of alloys expand; and some alloys show expansions with the Turner extensometer on cooling from liquid to solid, although the total volume change is a decrease.

The solid shrinkage is the contraction in volume of a metal or alloy on cooling from the solid state at the melting point to any lower temperature. It may be determined over any solid temperature range by experimental measurements or by calculation from the formula for expansivity. Ordinarily, in foundry practice, the solid shrinkage may be regarded as the contraction in volume on cooling from solid metal at the melting point to about room temperature. The thermal expansivity is the reciprocal of the solid linear contraction.

The linear contraction of a metal or alloy is the diminution of length that takes place in a casting on cooling in a mold. The terms linear contraction and patternmaker's shrinkage are synonymous. Turner states that the shrinkage may be defined as the difference between the length of a casting and that of the pattern from which it was produced — that is, it is the difference in volume between the fluid metal in the mold and the resultant casting at the ordinary temperature. Shrinkage in this sense, therefore, does not take into account the various stages of contraction, arrest, or expansion which may occur in an alloy, but represents the final volume change. In experimental measurements, the linear contraction may be most readily determined by measuring the diminution in length of a bar cast from a pattern of definite length. The linear contraction may be expressed in percentage diminution in length, in inch per foot, or in terms of the pattern-maker's shrinkage scale.

In pattern practice for light aluminum-alloy castings, the usual allowance for the shrinkage is 5–32 inch per foot; and if a casting is to be one foot long, then the pattern is made one foot and 5–32 inch in length. According to Keep, the general understanding is that the shrinkage of a casting is the difference in length between the casting and the pattern from which it was made; or rather between it and the mold in which it was cast. Thus, the general figure for the shrinkage of gray cast iron is one-eighth inch per foot, and the pattern maker, in taking measurements for the different dimensions of a pattern, uses a "shrink rule" which is one-eighth inch longer than the standard foot rule which is used to measure the castings. Shrinkage rules are graduated like the ordinary rule, but the spaces between the graduations are larger than the indicated space by an amount equivalent to the linear contraction.

As is well known in pattern making, current practice usually entails making first a master pattern in wood for any desired casting, and from this is cast the standard metal pattern to be used in production. This refers, of course, to jobs where a large number of similar castings is to be made.

Now, a pattern maker with little experience in nonferrous alloy founding, but required to rely on shrinkage data given in engineering handbooks, could not possibly make on one trial a wooden master pattern that would give cast metal patterns which would in turn produce castings of the exact dimensions required, with a minimum of "wasters." It is invariably necessary, even for skilled pattern makers, experienced in a variety of alloys, to cut away or build up portions of the metal pattern so that castings of the required dimensions can be poured. Thus, ordinarily, in the preparation of metal patterns for important repeat work in founding, it is necessary to proceed along the following lines:

First, a wooden master pattern is made with the usual allowance for contraction, and a metal pattern is poured therefrom. Then a few castings will be made from the metal pattern in order to determine where the defects occur and where the dimensions are incorrect, after which the required changes will be made in the wooden master pattern. Changes will continue to be made until a wooden master pattern is obtained which will give a metal pattern of the correct dimensions for yielding castings of the desired size. In all cases, the construction of a master pattern is based on the principle of cut-and-try, and when a rough figure is employed for the contraction allowance, the procedure is often lengthened interminably.

(Continued on page 294)

PUTTING RADIO TO WORK

By CAPT. H. W. WEBBE, U. S. A.
Captain, Signal Corps, Fort Leavenworth, Kansas

RADIO, like a child, has passed through a stage of adolescence. Different from most infants, its growth has been most rapid. We saw it at inception, a few years back, a mere dream. People were skeptical. Then came the disaster of the *Titanic*. A signal of distress was broadcasted. It was heard by passing ships. Succor was focused on what might have proven a total disaster. Radio was sold to the world. Huge antennae began to spread their invisible threads of communication into space, to distant points across the sea, emitting faint whispers in dot and dash, through the grind of static storms. Then came music, the human songbird, and the strain of a Kreisler was carried into the fastnesses of the forests and into the peasant home. The world has been gathered, as it were, into one large family circle, with the pacific influences which must ensue, all this because we have learned to utilize the electro static field. We have but touched the surface of this great little-known something, which our British and Dutch ancestors chose to term the ether. This same subtle medium has something very definite in its make-up, properties which resemble physical matter. It may be stretched, and caused to tremble, and this elasticity may be used, not only to amuse and carry messages, but to do definite work for man. Its possibilities as a servant are startling, both in peace and war. At the present time, it is quite possible to fill an aeroplane with tons of explosives and guide the same without a pilot over an enemy position, and to drop the infernal piece upon a place to be destroyed. It has a peaceful mission also. This brings us to the subject matter of this paper: "Putting Radio to Work."

The possibility of using radio for other than communication purposes was seen in the first coherer set of Marconi. An impulse could be passed through space, without a physical medium, which could generate enough force at a distant point to operate a relay. The relay made it possible to perform one task at a time, such as starting a machine, or ringing a vibrating bell, etc. Inventors began to improve on this, and a ratchet was devised to differentiate the impulses. By a series of dots and dashes the ratchet was moved, and various combinations were made. More than one task could thus be performed at a time. There are a number of interesting records in the Patent Office of the ingenuity of inventors who specialized along this line. Tuning forks were used in many of these. But the coherer was uncertain, and the advent of crystal detectors, and the first audion lamp, because of the feeble currents employed, rendered these early devices impotent.

The writer's active interest in radio control dates back to the fall of 1922 when he was asked to address a group of members of the American Institute of Electrical Engineers who were to assemble in a body at the auditorium of the Electrical Engineering College of Ohio State University. The writer selected the subject "Remote Control by Radio," and proceeded to build a model along the old established lines in this field. The results were most unsatisfactory, and so when my associate, Mr. Paul G. Edwards, suggested trying the use of tuning forks, the writer was reminded of this interesting possibility. We are all familiar with the phenomenon of sympathetic vibration. If we have two musical forks, of the same pitch, mounted on resonators, and we sound one, the other will vibrate owing to the disturbance in the air medium. Why not substitute the ether for the air. If I hold a fork to the transmitter of a radiophone, the note, with all its true characteristics, will be emitted from a receiver at a receiving station. Theoretically a fork of the same pitch held to the receiver should be actuated, and go into motion. This motion could then be used to close a contact, and by the use of a large number of forks, we would have instantaneous differential radio control. This "listens well," as the saying goes, but it is not practicable. What was actually done, however, after many sleepless nights and bitter disappointments, was to place an electrically vibrated fork, having long prongs and a low frequency, in series with the modulator circuit of a radiophone transmitter. This frequency, say one hundred twenty-five vibrations to the second, modulated the regular carrier wave, of say three hundred sixty meters. The receiver picked up this modulated note, detected it, and amplified it. The output was then put into a Western Electric loud speaker amplifier. A microphonic relay was connected to the output side of the amplifier. The relay, which is the patent feature of this system, then opened and closed a circuit at the frequency of the incoming pulsations. In series with this circuit were electrically vibrated tuning forks. That fork having a natural period of one hundred twenty-five vibrations would then go into motion. The motion of the forks closed and locked or unlocked certain relays which performed the desired work. The principle was successfully demonstrated to the Institute members who gathered at the University. By pressing a key the writer lighted an electric light at a distance, and by pressing another key turned the light out. The light was a symbol of power. Two tuning forks were used. The principle, if true for two, holds good for many. Any number of group of forks can be used so long as the frequencies are different.

(*Continued to page 300*)

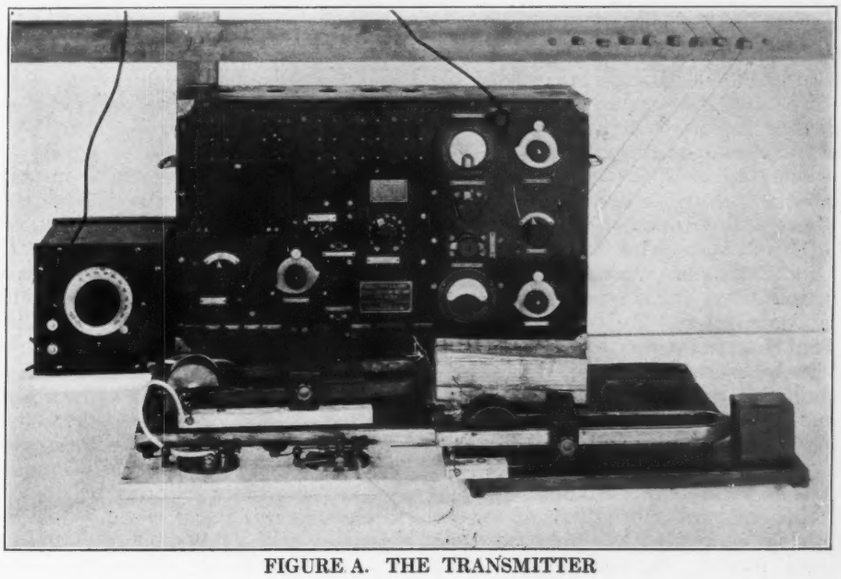


FIGURE A. THE TRANSMITTER

JAMES PHILLIPS BARNES

By E. F. KELLY
Louisville Railway Company, Louisville, Kentucky

NO man is a hero to his valet and by the same token, neither is he to his secretary. But, looking through the secretary's eyes, here is a man who, although his father was a banker, able to furnish him with the means of leading a life along lines of least resistance, started at the "bottom of the ladder" in railroading, and today is President of the Louisville Railway Company, Louisville, Ky., a $25,000,000 railway corporation.

His progress in the electric railway industry was not due to any so-called luck or "pull." The secret of his success lies in the fact that he never asked a subordinate to do anything he would not do himself, and will not even today, be it sweeping out the office or signing a dividend check. All of this is written simply to indicate to our student readers that a diploma does not entitle you to a living, but with good hard work and that diploma, you are certain to obtain a better living than otherwise.

James Phillips Barnes was born at Syracuse, N. Y., January 26, 1881, educated in the public schools of that city, graduating in due course from the Syracuse High School, and for two years attended Syracuse University as a special student in music.

"He took a hitch in his belt" and tried the entrance examinations for admission to Massachusetts Institute of Technology, where he entered in 1901, graduating in June, 1905, with the degree of Bachelor of Science in Electrical Engineering. Following his graduation he became connected with Pass & Seymour, Syracuse, N. Y., as a designer of electrical apparatus.

His analytical mind soon indicated to him that the problem of transportation, the oldest problem on the face of the earth, was a study deserving attention and one that would assure a life-time vocation.

"He took a hitch in his belt" in May, 1906, and became Chief Draftsman in the Engineering Department of the Oneida Railway Company. That Company was then engaged in the electrification of the West Shore Railroad between Syracuse, N. Y., and Utica, N. Y., by the installation of what is known as the Third Rail System. Later he became Assistant Engineer of that Company. The latter part of 1909 that Company having completed one of the then most modern railway shops in the country, which work was carried out under his supervision, his ability was recognized by the executive officers of the company and he was appointed electrical engineer in charge of the Syracuse Rapid Transit Railway Company, Mechanical and Electrical Departments. In February, 1912, he became Chief Engineer of the Syracuse Rapid Transit Railway Company, the Oneida Railway Company and the Utica and Mohawk Valley Railway Company, which companies are now part of the New York State railways.

JAMES PHILLIPS BARNES

"He took another hitch in his belt" early in 1913 when he realized that, coupled with his mechanical and electrical department experience, a broader knowledge of the problems of the operating department would furnish him with the key to the managerial field, and became General Manager of the Syracuse and Suburban Railroad Company. He was then but thirty-two years old and was heralded across New York State as the "youngest general manager in the State."

"He took another hitch in his belt" in October, 1914, and became General Manager of the Buffalo, Lockport and Rochester Railway Company, with headquarters at Rochester, N. Y., and on April 1, 1917, pulling the aforesaid belt a little tighter, he took on the more responsible position of General Manager of the Schenectady Railway Company, Schenectady, N. Y.

He tightened that belt around his constantly increasing girth until his waist-band resembled those of the famous beauties of the sixteenth century, and on July 1, 1920, he came to Louisville, Ky., as President of the Louisville Railway Company, where he found he had tackled a man's size job. He found himself surrounded by an organization "shot to pieces" by two strikes within twelve years and by war-time drafts; he found the revenues of the corporation insufficient to pay dividends by reason of increased expenses war conditions had produced; he found the management of the company in the midst of a campaign for a higher fare and a municipal administration professing to be bound by campaign promises to deny an increase, and with public sentiment, as revealed by those who usually give loudest expression of their opinions, bitterly opposed to financial relief for his company.

The fight for a higher fare, including an advertising campaign to change public sentiment, a losing battle in the City Council, and an appeal to the Federal Courts with victory in the end, is only part of the story. The big job, as he saw it, was to win public good will. All of these obstacles were surmounted, one by one, until today the Company is financially sound, paid a 2½ per cent dividend on its preferred stock on April 1, and another dividend of 2½ per cent on July 2, 1923.

When it became obvious that the income from operation of trolley cars was insufficient to warrant extension of lines and additional rolling stock to reach new fields and care for constantly increasing passenger traffic, officials all over the country began to cast about for means to meet this increased burden. Confronting them also was the increased automobile traffic on streets occupied by trolley tracks, which made the addition of more cars to an already heavy traffic a most serious problem. Mr. Barnes was among the first in the electric railway industry to study the possibility of automobile coach transportation to relieve this situation, and

(*Continued on page 302*)

THE ELECTRICAL ENGINEER ON SHIPBOARD

G. A. PIERCE
Chief Electrical Engineer, William Cramp & Sons Ship and Engine Building Company

THE definition of the word engineer, we find, is "one who is skilled in the principles or practice of any branch of engineering; one who has charge of and manages an engine" and an engine is "an apparatus for producing some mechanical effect." From the definition, the electrical engineer on shipboard does not exist today, although his wares are revolutionizing the loading, carrying, and discharging of cargoes. It is to be noted that we are not dealing with Navy or Government vessels, other than Shipping Board, as they have, to a great extent, pointed out the way and solved this problem for themselves as it developed.

The reason that he does not exist is very apparent. The first installation of dynamos and lighting on shipboard was in 1879 and the first power installation of note in 1894. Rules for installation of lighting were not issued until 1891, and those for power only two years ago. Thus we have a lapse of twelve years from the initial use to the date of rules for the installation of lighting and twenty-six years for those of power. The work of installing the plants was left largely to the shipbuilder and owner and were it not for the experience gained from building construction and naval work the mishaps and fires at sea due to electricity would be many times multiplied.

Steam and motor, or combustion, engineers are required to satisfy those in authority, the Steamboat Inspection Service, that they are skilled in the art of steam or combustion engines and are rated and licensed by their training and knowledge. Practically no electrical experience is required of the steam or motor engineer and, on the other hand, no electrical engineers are required on board ship. Further, the requirements for periodic inspections of the electrical plant on shipboard by the Steamboat Inspection Service and the insurance societies do not compare with the periodic inspections required for other forms of power.

The present age of electricity on shipboard is analogous to the advent of steam and combustion engines for shipboard use as the first of those types were operated under much the same conditions as the electrical apparatus of today. It is only recently, 1920, that combustion engines were recognized for ocean use in this country and the necessity found for requiring those in charge of the machinery to satisfy the authorities of their ability to properly maintain the machines before a license would be granted. A similar condition was recognized in 1852, when it was found expedient to replace sailing vessels with steam vessels and requirements were made for knowledge of steam engines for marine use before a license would be granted.

The electrical engineer has done well to date, considering that his knowledge has been gained by his own initiative and the hard knocks of experience, in caring for the electric plants. There have been cases, however, where the knowledge of the engineer has not been equal to the occasion. On one ship the repeated blowing of a fuse on the switchboard was corrected by installing a piece of No. 8 copper wire with the result that the circuit was burned open behind some panel work. In another case one of the engineers observed the temperature of the cooling water on a motor-driven pump was high. He had come by the knowledge somehow that by shifting the brushes on a motor the speed could be increased. This he proceeded to do, to increase the flow of water rather than look for the trouble elsewhere. The result was that all the conductors were thrown out of the armature. It was completely ruined and had to be rewound. I can say that these conditions are general rather than the exception and represent the conditions as they exist today.

We have found the marine engineer needs considerable training in electricity, which he has not had, so much so that we have recommended to the owners they carry an electrical man. To better enable you to appreciate the extent of the electrical plant on this type of vessel, every auxiliary on the ship, steering gear, windlass, capstan, deck winches, engine room, bilge, sanitary, fresh water, salt water, lubricating, cooling pump and compressor are motor driven.

Therefore, you will readily see that success of the main engines and the vessel at sea depends on the success of the electrical auxiliaries and on the deck auxiliaries for the handling of the cargo at the dock as the owner realizes the return on his investment from the combination of these features and not from independent sources.

You can readily appreciate the electrical engineer started with some handicap which, no doubt, dampened his ardor for his new position and gave rise to feeling among some licensed men who were paid less than the electrician. This feeling in one case did not exclude the Chief, who threatened that when he got to sea he would assign the electrician to the most menial job one could imagine. Fortunately, the electrician in this case was also a diplomat and in a very short time was almost inseparable from the Chief and that Chief is now in a fair way to become an electrician.

In some large passenger ships, having a plant load requiring four 100 k.w. sets, the electrician is paid more than some of the engineers. On other ships of 15,000 tons the electrician is paid as low as $75 per month, less than two thirds of the lowest paid engineer, and only slightly more than an electrical helper on shore working forty-four hours per week.

The duties of an electrical man on a motorship are such that he has replaced what would be the deck engineer on a steamship, having in his care the maintenance and operation of the electrical and mechanical features of all deck machinery, steering gear, winches, capstan and windlass and ice machine, the supervision of all engine room motors, generators and switchboard. The universal success attending all of these ships in operation would indicate that the attitude of the builder and owners has been well taken in regard to the selection of men. However, they should be assisted by the authorities by laying down some rules for the training and licensing of competent engineers for electrical plants or electrical engineers, in order that the matter may be handled with some uniformity and the owners be assured of obtaining competent men. This is particularly so when it is considered that electrical installation amounts to twenty per cent of the total machinery in the vessel and is absolutely indispensable.

The question naturally arises, how is the problem handled on ships under other flags. In the Scandanavian countries, the conditions are pretty much the same as in our country. The larger vessels carry electricians and are rated in pay about as the second engineer. In the British ships, electricians are not licensed as such, but frequently licensed men are electricians, as on some motorships and large steamships with extensive electrical plant. The electrician ranks in pay almost equal to the first assistant engineer and the latest motorships carry a chief, first and second assistant electrician.

ALDRED LECTURES

THE DEVELOPMENT OF LIGHTING AND POWER SERVICES IN A GREAT CITY

By JOHN W. LIEB
Vice-President of the New York Edison Company

I wish to say, gentlemen, that I am deeply appreciative of the honor of being invited to deliver one of the lectures of this course, invited by Dr. Stratton, a very old friend of mine, whom I deeply respect and whose work while he was Chief of the Bureau of Standards has not yet been fully appreciated by either the technical world, the scientific world or by the American public. He did one of the most notable pieces of war work which was done anywhere by anybody, and it has left a lasting impress on American science and American industry.

I also appreciate very much being tendered this invitation to address you through your distinguished alumnus, Mr. Aldred, a type of man who combines in an extraordinary way the engineer, the executive, the financier, the man of broad imagination and attainments. I appreciate this very deeply because I have the honor to be associated with Mr, Aldred on the Board of Directors of the Italy Power Company, as that institution has set itself the task to aid in rehabilitating industrial Italy and assisting her in her expansion of hydro-electric power, associating its work, as one of its first elements, the assistance in financing the old company in Milan which I had the honor of starting.

The subject we have chosen for this address, "The Development of Electricity Supply in a Great City," while a local phase of the general problem of the availability of an abundant supply of reliable and cheap power throughout the country, is nevertheless of great significance in the national economy, as it lies at the very foundation of national prosperity. The electricity supply of our great cities, with their ever widening territorial development, its expansion into great systems, and then their interconnection into interstate systems, ministers in an ever-increasing degree to the convenience, happiness and health of all the people, and it therefore becomes truly a national problem.

We can hardly appreciate, as we scan the pages of history, the immense tasks that confronted the ancients in executing their colossal structures — the pyramids of Egypt, the monumental structures of Babylon and the East, the temples of Greece, the aqueducts and public monuments of the Romans, and down to the memory of men still living, we must recognize the almost insurmountable difficulties which stood in the way of making men — even armies of them — perform tasks for which the puny effort of integrated man-power, developing as he can individually only one-eighth to one-twelfth of a horsepower, is quite ineffectual.

We remember the statement in our textbooks of that early pioneer in providing mankind with power, James Watt, to whom we owe many of the early improvements in the steam engine, who, in making his application for British letters patent and explaining the promise disclosed by his inventions, said: "I have what every subject of your Majesty needs — Power."

The modern engineer who has at his command such marvels of mechanical science that a single one of his power units represents the combined power exerted by nearly a million of men, and who, with the aid of the sister science, electricity, can deliver that power hundreds of miles away and readily split it up for practical application into units of the smallest size, must surely sympathize with the ancient builder and craftsman deriving his power only from man and beast, with possibly a little water power of limited potentiality.

So important has become the availability to modern productive industry of an abundant and cheap supply of power that sociologists have come to regard the extent to which power is utilized by a nation as not merely indicative of the degree of emancipation of labor from its heavy menial toils and perspiring drudgery, but as an index of the nation's industrial supremacy and productive efficiency.

It would lead us too far afield to traverse the annals of history from Archimedes and Nero of Alexandria, and we must skip over many pages to the names associated with the many modern inventions which have brought power production and distribution to their present high states of efficiency and placed in our hands resources undreamed of but a century ago, and which have in their manifold applications revolutionized all human relations.

We can more profitably, but not more interestingly, perhaps, limit ourselves to the relations of power production and distribution in connection with the industry in which we are more immediately interested in our presentation — the electric light and power industry.

While the steam engine and its accessories, the steam boiler and the condenser, had reached a certain stage of development antedating the invention of the dynamo-electric machine, their development received an enormous impetus through the introduction of this new instrumentality of power application some fifty years ago; and this brings us down to the central station for the production and distribution of power in the form of electrical energy, which may well be taken as the background for our present discussion.

Prior to 1880 there were a number of central electric stations in this country and abroad, but their service was confined exclusively to series arc lighting, and for years afterward these stations played only an insignificant role in interior lighting service through the very limited use of series incandescent lamps, when they became available after 1882.

These arc stations cut still less of a figure in the field of the distribution of power, only a very limited application being made of a series motors on the series arc circuits, all of which were at first overhead, strung on wooden poles. In New York, as in other larger cities, a number of com-

panies were incorporated in response to the insistent demands of the public for the installation of the brilliant new illuminant, and franchises could be had for the asking, each manufacturing company seeing to it that its particular system was represented in the promotion rush.

In New York a few months ago we took part in the celebration of an important date which marks an epoch not merely in the electrical industry but also in the annals of power production and distribution. I refer to the starting of the historic Pearl Street Station in New York in September, 1882. It was distinctly the prototype of the modern central station and represented in its mechanical and electrical equipment many of the conspicuous features of the best power station practice for many years thereafter, and even of the present day. It was, however, a noncondensing plant, and while we do not have complete data from log sheets or other operating statistics, we know that the water rate of the plant must have been close to thirty-five or forty pounds per horse-power hour, representing a coal consumption of from six to seven pounds of coal per kilowatt hour at the busbars at full load, and much more as the yearly operating average.

As we have seen, there were stations in operation at the time supplying arc lights from belt-driven dynamos, directly through countershafts, with power supplied by Corliss-type slow-speed single and compound condensing engines, and these had lower water rates. High-speed engines, single and compound, became popular, driving forty- and fifty-light series arc machines; but all of these stations distributed only insignificant amounts of power as electricity, and the development of power on any considerable scale exclusively for local use was confined at that time to water-works engines, mill engines and a few larger industrial plants. It is a matter of regret that we may not follow the evolution of the prime movers with which electric light and power and electric street railway plants were equipped, and with which we associate such familiar names of engine builders as Corliss, Howes & Philips, Reynolds, Greene, Armington & Sims, Porter-Allen, McIntosh and Seymour, Ide, Sweet, Westinghouse, Safety, Hoadley and others, and well-known names associated with boiler equipment, such as Babcock & Wilcox, Heine, Stirling, Root, Morrin, Manning, Hazelton, Wickes, and the leading exponents of the generic boiler types, such as the Lancashire, Scotch, Cornish, Galloway and other return tubular boilers.

We must also pass over the evolution of furnace types and mechanical stokers and content ourselves with a mere mention of the names of the pioneers in turbine development, Curtiss and Westinghouse in this country and Parsons, De Laval, Rateau, Zoelly and Stumpf abroad.

Having hastened over our brief historic review, we are now prepared to consider some of the fundamental economic principles underlying both power production and distribution, and then proceed to consider some of the characteristics of the service rendered by these public utility plants.

Right here let me say that I know of no engineering operation in which comparisons are so difficult, and in which the results of such comparisons, and the conclusions that may be drawn therefrom, are so unsatisfactory and inconclusive as comparisons between the economic operating costs of the power houses of different public utility companies. The types of equipment, that all-important element, the date at which their equipment was purchased and installed; the number and size of the units, the conditions of supply of feed and condensing water, the load factor — daily, seasonal and yearly — the capacity of units held in reserve, types and characteristics of coal consumed and accessibility to rail or water transportation for receiving it and disposing of ashes, types of furnaces, stokers and draft equipments, and the location as determining the design of the plant — all of these with numerous others are factors affecting the economy of operation and plant efficiency, expressed in pounds of coal or British thermal units per kilowatt-hour of electrical energy generated, all of which factors make efficiency comparisons between different plants very difficult. Until all of these factors are definitely known and properly evaluated — a most difficult and time-consuming task — such comparisons are perhaps interesting, but practically they are merely approximative where they are not altogether valueless. Also in the matter of distribution and transmission expense and efficiencies, true comparisons are only possible after exhaustive consideration of innumerable elements, such as extent and characteristics of territory and population, density and character of distribution, the available market, etc.

In considering the economics of power generation, the first primary essential is a knowledge of the character of the load and its physical limitations of production and demand.

In most cases the character of the land is expressed broadly in terms of the load factor, that is, the average load over a stated period of time divided by the maximum. The total expense on account of investment and the expense of operation and maintenance of almost every kind of equipment used in electric service change relatively little on account of changes in load factor, except the expense for coal. These expenses per unit of output are therefore relatively low for high load factors and are relatively high for low load factors. The same situation also obtains to a large extent in regard to general expenses, so that the load factor of the service rendered is an exceptionally important element in the total cost of furnishing electric service. It is also an important factor in every phase of human existence where there are large variations in the demand for services rendered, whether the endeavor is represented by the work coming over your desk or coming to your business department, whether it is in the operation of a bootblack stand or of a railroad, in the operation of a rest room, a hotel or an ocean liner.

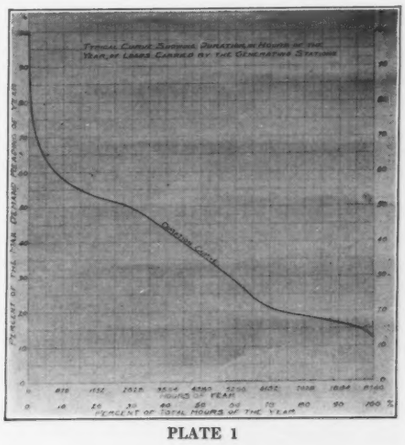


PLATE 1

While the load factor is the most important load characteristic, the minimum load should be known as well as the maximum load, together with the distribution of the load between these limits during the year and shown by a "duration curve."

I would like to direct your attention to this curve, because this curve contains in it the elements for any discussion of the economics of power production and of any comparison which may become necessary between a hydro-electric power transmitted and steam power.

You see here (referring to chart) we have an expression of the percentage of the maximum demand reading of the year, whatever that may be. We have here as the abscissæ the percentage of the total hours per year, and we have here these hours expressed numerically. Now you take here, for instance, fifty per cent of the load. Fifty per cent of the load can be delivered through 2,616 hours, or

thirty per cent of the total hours of the year. The maximum load, which is, roughly, ten or twelve per cent of the maximum load — that, of course, is the minimum and that can be operated during 8,760 hours of the year, or one hundred per cent.

Now this duration curve shows the extent to which any given load may be operated under the demand put upon it by the central plant, and is the very fundamental of the mechanics of power production in a central station system. It enables the designer to so proportion his installation that the apparatus may be run at its economical rating most of the time. Continuity of service predicates reserve equipment to obviate trouble should one or more of the units be put out of service through accident or by reason of cleaning, repairs or the processes of ordinary upkeep. Readiness to serve implies ample reserve and the running of units at a lower rating, perhaps below the point of minimum economy, to provide for sudden unexpected demands. This question brings up the question of so-called overloads, which were readily carried in time of stress by the more flexibly rated prime movers of the past years. It has been the policy of the manufacturers, however, for a number of years to rate turbogenerators at the maximum power that they are capable of delivering, the power station depending upon extra machines for supplying peak demands and overload capacity.

Theoretically, the efficiency of a heat engine depends solely upon the temperature limits of the working cycle of the heat medium and is independent of the size or output of the apparatus. Unfortunately, leakage, radiation and friction all tend to reduce the power generated by the apparatus, and while the theoretical limits may hold in general, the effect of these losses nevertheless tends to make the larger apparatus more economical. As the size of the prize never increases, these losses, although increasing in absolute amount, will nevertheless be a constantly decreasing percentage of the heat input of the prime mover, and it is for this reason that the larger prime movers are more efficient. With good design, better and more careful construction and the best of operation, the steam engine efficiency curve referred to size of unit flattens out very quickly at 500 to 600 horsepower, and beyond this point gains very little up to 15,000 to 20,000 horsepower, the minimum size constructed. Steam turbines obey the same general law, but with the added complication that the bucket speeds are usually a compromise between the theoretical speed as deduced from the velocity of steam through the nozzles and the allowable speed due to strength of materials or to the electrical conditions necessitated by the impressed frequency. The steam turbine, however, has been built on a single shaft up to 60,000 to 70,000 horsepower, and with a combination of shafts may be carried to perhaps 100,000 horsepower.

As the size of generating stations increased before it was possible to build large units, a greater number of small units was necessary in some cases to carry the load, and this is apparent in metallurgical power plants, such as Gary, where twenty-five or more units of the maximum size (internal combustion engines) were necessary to handle a high load factor demand. Even in many electric lighting stations prior to the development of the turbines a large number of engines of the maximum size (6,000 k.w.) was necessary to do the work.

The steam turbine has developed into a nearly ideal instrument of power generation because of the facility with which it may be built up to large sizes and the economies which have been secured by its use together with the facility with which it can be connected to suitable electrical generators. It has been stated by some authorities that a minimum of three and a maximum of five units should constitute the ideal generating plant and that such combinations will give the maximum flexibility with the minimum losses. Modern aggregations of power, however, are of such a size that this rule cannot be followed and at the present time the larger central stations (super-power stations) use the largest size unit obtainable and as many of them as may be necessary to meet the maximum demand.

Any operating mechanism must of course be kept in repair, cleaned and adjusted, from time to time, in order that it may do its work in an efficient manner. This maintenance must be done at stated intervals and unless these intervals occur at proper times relative to the load, reserve apparatus must be installed to meet the demand. In a steamship this overhauling and repairing is done at the end of every voyage while the ship is in port. On the locomotive it was formerly done at night but is now taken care of by temporary replacement with reserve apparatus. In power stations it has been customary to install reserve units in sufficient quantity so that the maximum station load can be carried with one of the largest machines out of service, and major repairs and adjustments are made in seasons of light demand, *i.e.*, usually in summer time. This usually light season sometimes brings with it difficulties in the shape of sudden thunder storms with their accompaniment of inky darkness and we have as a result that in New York, for instance, the load in full mid-summer may rise to an amount almost equal to the previous winter's maximum. Hence, here we cannot be said to have available spare off-peak capacity even in summer time.

Let us now come to some concrete examples of these principles and their actual effect on the economics of power production.

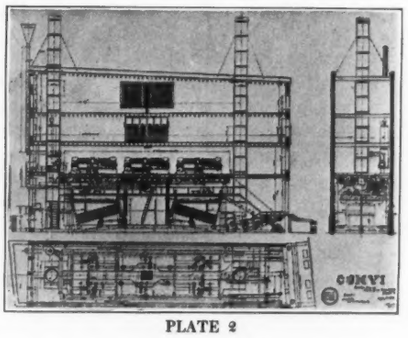


PLATE 2

In Plate 2 is shown sections and a plan of the pioneer Pearl Street Electric Generating Station already referred to, which commenced operation on September 4, 1882, and continued in service until 1895. With this station and the accompanying distribution system which it served, Mr. Edison initiated the era of central station electric service and demonstrated the broad practicability of what Sir William Preece in company with many other contemporary scientific men at the time, designated "an absolute *ignis fatuus*."

Now here you have this old pioneer power plant before you in an old sketch, and you will see the old Jumbo machines of a 1,000 to 1,200 horsepower, which were located above the ground on an elevated trestle, the boilers below. I show that particular equipment that attention may be directed to the fact that all of the auxiliaries, the blowers for furnace draft, the coal and ash handling apparatus and heaters, the connection to the chimney — all of these here, including and emphasizing the direct connection of the unit, directly connected to the dynamos — constitute a prototype of the latest type of practice. I would like very much to be able to point out some of the other elements of this extraordinary and anticipatory plant, such as the system of distribution, at first two-wire, low-tension, direct current, of course, and then later, three-wire, and some of the interesting methods that were used at that time for determining the number and location of the feeders which fed into the general systems so as to produce a uniform pressure in the net-

work, the network covering roughly about one square mile of territory. But we must pass on.

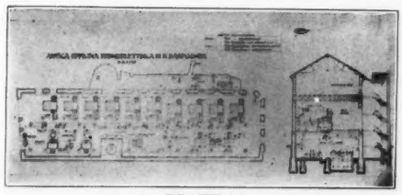


PLATE 3

In Plate 3 is shown another early electric generating station which has played an important part in the development abroad of electric lighting and power service. This is the Milan, Italy, station which commenced service in 1885 and continued in service as a generating plant until 1889.

These stations have a special interest for the writer, inasmuch as he was the electrician of the former at the time of its installation and early operation in 1882 and of the latter he was in charge of the electrical installations and operations for many years, beginning with the year 1883.

Since the period of these stations steam engines as prime movers in electric generation have become substantially obsolete and have been superseded by steam turbines. This almost complete supersession has nearly all taken place within the past fifteen years.

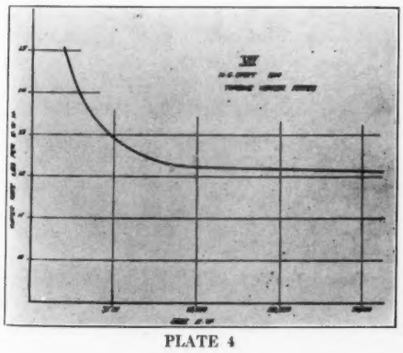


PLATE 4

As an index to the vast improvements in the water rates of steam turbines, that is, the pounds of steam required per kilowatt-hour of energy generated, of the steam turbine generator units during the past two decades, we may inspect Plate 4 giving a curve prepared by a distinguished central station engineer, the late Mr. Henry G. Stott, in 1915. It should be noted that the figure as "best" has been greatly improved upon as appear in the water rates of later types — of more recent design — the data of which appear in Plate 5. It should be noted that the water rate of the Gonvilliers (Paris), Hell Gate and Brooklyn units (the same as in Hell Gate later) are "guaranteed" or "specified" water rates, while the Interboro 74th Street data is the result of actual test.

Let us now consider the characteristics of the load or demand as revealed by the load diagrams of a characteristic station. It is interesting to note that in the case of the New York stations there has been a considerable improvement in the load factor since 1900, an increase of from twenty to twenty-two per cent to thirty-six to thirty-seven per cent at the present time. This steady improvement represents the filling in of the "valley" of the typical load curve, that is, the low load periods of demand on the generating stations both daily and seasonally. This is due to the greater diversification of the uses of the installed translating devices and the addition of railway load to the ordinary lighting and power load, the promotion of new uses for the current in various electric appliances and industrial applications, and the stimulation and encouragement of new classes of business which help the load factor either through diversity or through inherent load factor.

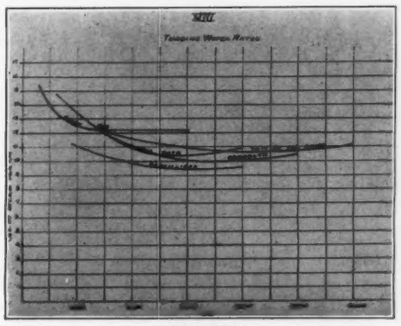


PLATE 5

It is found that the load during the day has increased relatively more than the increase in the evening peak. We find that there has been also a gradual improvement in the seasonal distribution of the load, and the summer load, particularly on the direct-current system, is being gradually built up. This improvement is undoubtedly a result of the increase in the power load largely for building construction. It is observed that the bulk of the power load for this purpose goes off before 4.00 p.m., and therefore contributes relatively little to the five o'clock peak.

Regularly high monthly load factors throughout the year are of greater importance from the standpoint of operating economy than a high annual load factor; but it is the annual load factor which is the important factor from the standpoint of the investment necessary to be made for equipment.

Now here is a curve that was finished just a few moments before I left New York last evening, and as far as I know, it is the first time that there has been brought together on a comparable diagram all the diversified public utility services of a great city. This affords a very interesting sociological study. As you see here, we have a load diagram of the New York Edison Company and its allies, which is this one, and you see the tremendous peak at five o'clock, this being a winter diagram. We then look at the traction load, which has the interesting characteristic that it becomes very heavy at nine o'clock in the morning to bring people down to their business, and then it falls off, and again has a second but somewhat smaller peak in the afternoon, but still is almost coincident with the lighting and power peak, except that it extends along a little longer for the people to shut down the lighting in their offices and start to go home.

You see here the telephone peak. This has the characteristic that its maximum is at eleven o'clock in the morning. It then falls down during the luncheon hour, and then people begin to talk (laughter) and so falls off. But the interesting part is the very, very small and insignificant load during the night, when people do not talk to the outside through the central telephone station, but they talk in their sleep. (Laughter.)

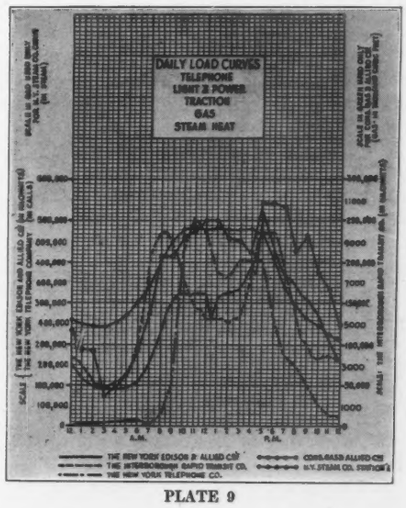


PLATE 9

You will note here, also, the send-out of the gas service, which is a maximum again at five o'clock; but, you see, due to the enormous amount of gas used for cooking purposes, it extends well along to seven o'clock and then falls off.

And then again another interesting curve is shown here in the steam-heating curve, which you see comes on early in the morning, is kept on pretty steadily throughout the day (on a December day) and then falls off.

As I say, this diagram brings together all the public utilities and is a most interesting epitome of the habits and customs of the people reflected in the demand that they make for public utility service.

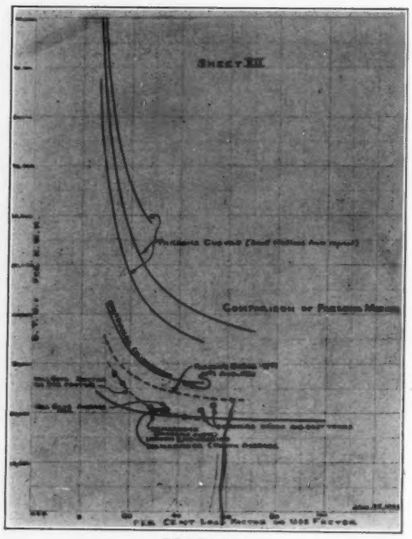


PLATE 10

We may now endeavor to visualize the effects of load factor on the water rates or British thermal units required per kilowatt-hour of energy generated, which is the measure of generating station economy.

Here you have some of the comparisons in Plate 10, which shows the British thermal units per kilowatt-hour generated with relation to load factor, as plotted by the Parsons method, where the total coal per watch is plotted against kilowatt-hours. The three Parsons curves are taken from his article in *London Engineering*. The lower curve of the Delmarneck

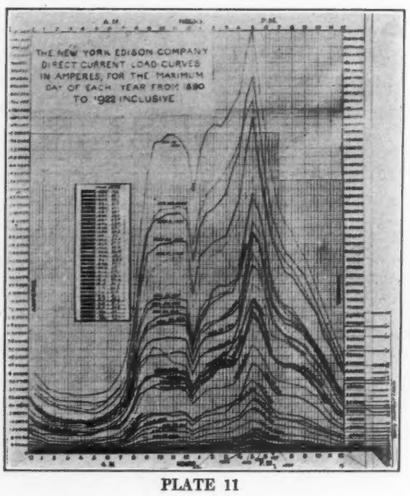

THE NEW YORK EDISON COMPANY
DIRECT CURRENT LOAD CURVES
IN AMPERES, FOR THE MAXIMUM
DAY OF EACH YEAR FROM 1890
TO 1922 INCLUSIVE

PLATE 11

Station is also taken from *London Engineering*. The Eberswald (Germany) curve is taken from Dr. Klingenberg's records, while the New York Waterside No. 1 and Hell Gate curves are plotted from the records of regular monthly runs. The isolated points represent yearly or monthly averages plotted against the respective load factors.

It may now be interesting to present some phases of our subject as exemplified in the development and operation of the Edison and United Companies in New York City. I shall endeavor to do this through the medium of drawings and charts showing some of the generation, transmission and distribution features of these companies.

In Plate 11 are shown the load curves of the direct-current electrical system in Manhattan *for the maximum day of each year* since the year 1890. The loads are here shown in amperes (each equal to about one-eighth of a kilowatt), as the ampere is a convenient unit to use with this class of substation load; also at the time the earlier of these curves were drawn, the kilowatt and kilowatt-hour units were relatively little used in central station statistics, The lowest curve represents a maximum demand of 1,640 amperes, whereas the highest one represents a maximum demand of 2,120,000 amperes, roughly300,000 k.w.

Now I would like to call your attention to one or two things. I am afraid these figures are a little too small to be appreciated, but here are the load factors of each one of these curves. These curves visualize the actual building-up of the chief electrical load in Manhattan during the past third of a century. The indicators on the scale at the right, referred to the peaks of their respective curves, show the relations of the average annual loads to the respective maximum loads, representing the annual load factor. The inset table shows the gradual increase in load factor by year since 1890, when the load factor is as low as seventeen per cent, whereas in 1922 the diagram shows 33.7 per cent, which means that each unit of capacity of much of the company's equipment supplied nearly twice as much electrical energy for sale during 1922 as during 1890.

Here we have these yearly amounts given, so that they can easily be traced when the record is before you. But I wish to emphasize particularly the mathematical exactitude with which the minimum load of the day is at half past twelve and the unfailing regularity with which the maximum always comes at five o'clock for each of the thirty-three years presented — and you will notice that Alpine peak which it assumes during the winter months. This shows how little the confirmed habits of men change, even in decades.

Coming now to the total loads on the New York generating stations, on Plate 12 are presented the total system load curves of the Edison and its allied companies, all combined for the maximum day of each year from 1916 to 1922 inclusive.

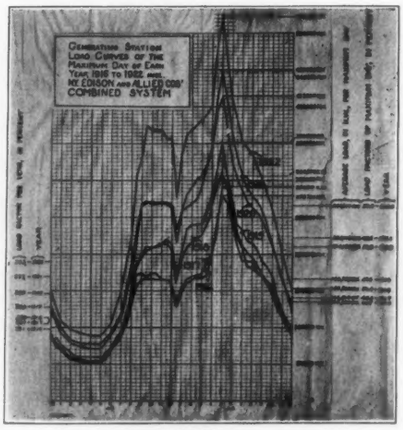


PLATE 12

There is little difference in the configuration of these curves from those shown previously (on Plate 7), except that the night loads in these are relatively a little greater than the others, that is, the valleys of the load curves are slightly better filled. The annual load factors are a little better for the total system than for the direct-current system. This is accounted for by the combined effects of higher load factors of some of the alternating current, high-tension services (serving directly as high tension to ice plants, for which that service is practically

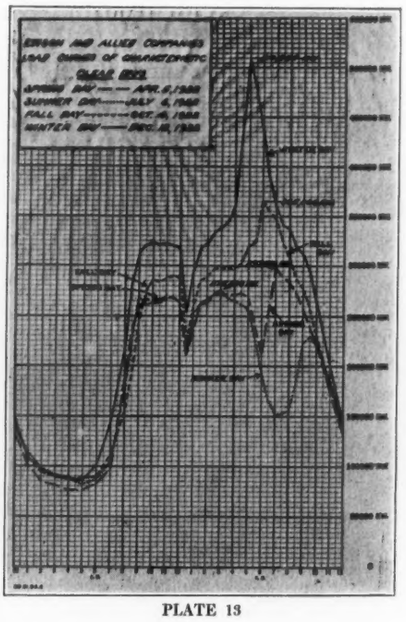


PLATE 13

exclusively devoted) and the lack of coincidence of the maximum demands of the widely separated territories

served, many of which are suburban territories. On account of the latter the combined maximum demand becomes less than the sum of the individual maximum demands, thus creating a considerable diversity factor between the two territories supplied.

Plate 13 shows load curves for a typical clear day for each of the seasons of the year; in other words the seasonal variations. It will be seen how the day load of all the days rises to three and a half times the night load, and how the winter evening peaks tower to seven times the minimum. You see that in a summer day the load goes off at six or seven o'clock, then goes down at seven or eight o'clock, and then again there is a kind of a secondary peak, due to the considerable use in theatres, restaurants, and so on, from the spring to the fall; and then the minimum winter day, where there was 510,000 k.w. on December 13, 1922. No way has so far been evolved to fill up the night valleys or to eliminate the winter peaks. Man is naturally a daylight worker, but he insists on working after the winter dusk, provided he does not exceed the traditional eight-hour working day. He will not and should not work at night unless the industry in which he is engaged requires it. Also, there are sixty-two Sundays and holidays in each year which give a little more than the night load carried through the twenty-four hours, and fifty-two Saturdays, when the major part of the normal afternoon load disappears. So that after all, with all the development possible, with all the efforts made to obtain uses for the electricity supplied, encouraging electric vehicles and anything that might help to build up the peak, it has only been possible after all these years of effort to reach a maximum of thirty-six or thirty-seven per cent of the possible maximum output in the Metropolitan

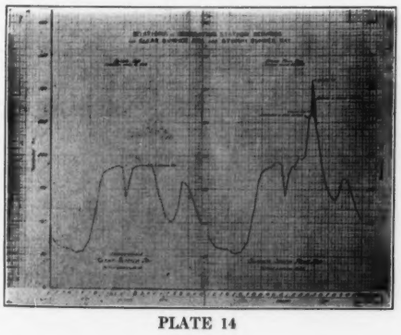


PLATE 14

District. This figure is, however, notably exceeded in stations supplying continuously operating industries, such as electrochemical or metallurgical plants.

The sudden inky darkness into which Manhattan is sometimes thrown from normal midday summer brightness, within a period of minutes, has already been referred to. Plate 14 gives a picture of one of these occurrences in 1919. The left-hand curve shows the maximum station demand that would normally be expected on a clear day at that season of the year. The right-hand curve shows what one of these freak thunderstorms may do to us. At two-thirty o'clock a demand of 200,000 k.w. is shown, which might be expected on an ordinary stormy day; but this storm was not of that kind, so that, between three-thirty and four, the load has risen twenty-five per cent, and from four to four-thirty, another twenty-five per cent, rising to a point higher than any previous maximum demand on the system. The shaded portion of the curve shows how the storage batteries come into play to hold the Manhattan voltage even, so that not the slightest effect of the tremendous burden of 100,000 horsepower or more suddenly thrown on the system was apparent in the service.

In the case of central station electric light and power service it is possible to visualize the development of a revolu-

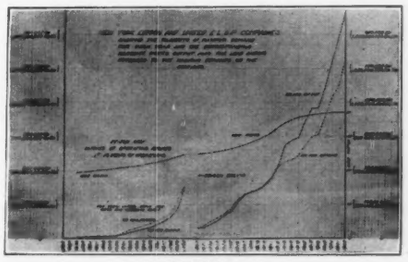


PLATE 15

tionary art for the entire time since its inception through the operation of one of its prominent exponents — the New York Edison Company. In Plate 15 the development is shown from the beginning of the service with the old Pearl Street Station in 1882 by the Edison Electric Illuminating Company and continuing through the later combined operations of the New York Edison Company and the United Electric Light and Power Company and their allies to the present time. There is here shown the yearly maximum demand on the stations and the corresponding kilowatt hours output beginning with the small area in the Fulton Street district, at the inception of the service, and expanding to service from a single great combined generating and transmitting system covering the entire territory of Manhattan, Queens, Bronx and all of Westchester County, extending from the tip of Manhattan Island to the Putnam County line, the limits of the franchises, a distance of forty-five miles. These curves clearly show the condition that the increased requirements for electric lighting and power service are as great today as in the past, and we are therefore still far from attaining saturation. During the past ten years the energy generated has increased three-fold and there appears to be no diminution in the rate of increase. The load factor is gradually but slowly improving, the rate of improvement being dependent upon the increasing diversity of uses for the electrical energy.

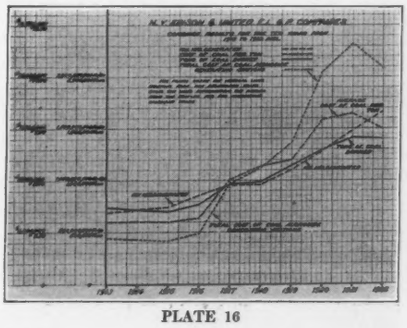


PLATE 16

Here you see the whole history. It has been cut in two because the relation of ordinates to abscissæ would not have been significant if this was flat and the left-hand part of the curve were preserved. But you can see here the fuel climbing up on the load factor and you can see the kilowatt hours output have increased more rapidly than the kilowatts of maximum demand which are shown for each successive year.

Now, I would say that there is still much to be shown here and I will have to skip a lot of it because time is passing rapidly. I would like very much to touch upon the transmission and distribution systems as well as the important functions in a public utility of the administrative and commercial parts of the system, but it would be possible only to refer to these most briefly.

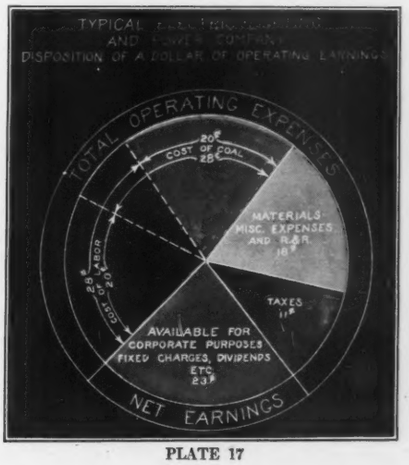

TOTAL OPERATING EXPENSES
COST OF COAL
MATERIALS MISC. EXPENSES AND R & R
TAXES
AVAILABLE FOR CORPORATE PURPOSES FIXED CHARGES, DIVIDENDS ETC.
NET EARNINGS

PLATE 17

The situation relative to price and quality of coal has given station operators grave concern during the

period from 1916 to the present time and in Plate 16 this condition is diagrammatically presented. Plate 16 shows the total kilowatt hours of energy generated by the Edison and United Companies, the total tons and total cost of coal consumed, and the per ton cost of coal alongside the generating stations.

It is worth while in considering this subject to see what may be considered as a typical disposition of a dollar of operating earnings in its relation to the several main divisions of expense. In Plate 17 is presented a chart which may be considered as showing this for a typical large electric lighting and power company supplying a territory having great density of population in some parts and relatively small density in others. It will be seen from this that the cost of fuel is an important item, yet this may actually amount to

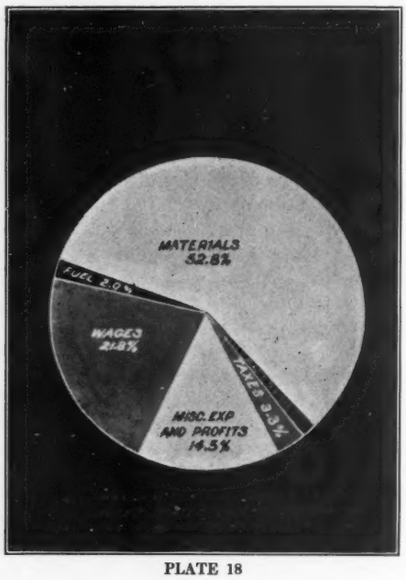


PLATE 18

less than 20 cents out of the dollar, though it also may be as high as 30 cents, this relation depending upon both the location of the system and upon the characteristics of the loads, that is, whether a very large amount of the energy is sold in bulk or whether a relatively small porportion is disposed of in this way.

Here you see what becomes of the dollar that is earned by a utility company, and it is reasonably typical, of course varying somewhat according to local conditions. The cost of labor in two plants here, in one case is 20 cents out of the dollar of income, in which case the cost of coal is 28 cents. In the other, the cost of labor is 28 cents and the cost of coal, 20 cents. Materials and expenses, 18 cents; taxes — 11 cents out of the dollar go to the payment of federal, state and municipal taxes. There is left available to pay interest on the bonds, dividends, resources, etc., 23 cents out of the dollar, representing the fixed charges as they are called.

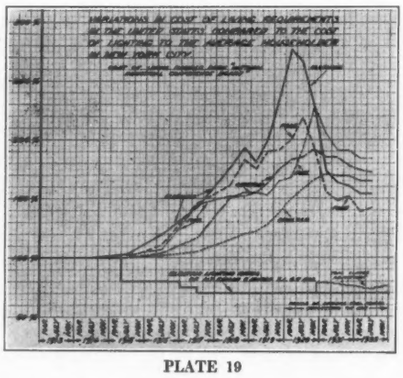


PLATE 19

It is instructive to compare this diagram with that shown on Plate 18, wherein approximately comparable data are shown for the manufacturing industries of the United States for the year 1919, excluding gas manufacture, blast furnaces, steel works, rolling mills and petroleum refining. Here the element of fuel cost is less than two per cent of the total revenue, showing what a relatively small factor it is to industries generally as compared with the cost of fuel in furnishing electrical service.

Of the cost of living, electric service is the only material expense which did not increase notably during the World War. All other living expenses increased tremendously during this period, while the cost of electric service actually decreased to the householder from twenty to thirty per cent. This is shown in Plate 19. You will notice on the chart how everything else has skyrocketed. All other living expenses increased tremendously. That diagram itself would bear very interesting investigation and study. The electric light rates are below here, but you will notice that in 1920, due to these tremendously high fuel costs, the regulatory bodies permitted the addition to the normal rate of coal adjust-

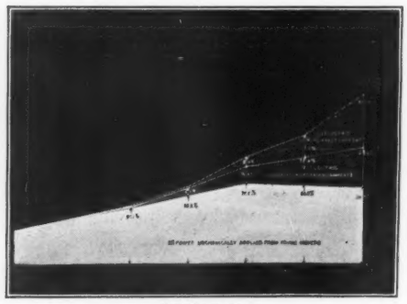


PLATE 20

ment charges, comparable with the additional cost of coal.

As you will appreciate, central station electric service is now almost universal for residence and commercial electric lighting and power wherever such service is available, and its present growth in industrial establishments is tremendous, as shown in Plate 20, taken from the United States Census reports. You will notice here what an enormous part is being played by the purchased electric current; how very much greater that is in these later years than the prime movers in ordinary industrial establishments or electricity generated in the ordinary establishments. Thirty-five years ago there was substantially no electric energy purchased by industrial establishments, whereas in 1919 nearly a third of the industrial power equipment received purchased energy as its motive power. Since 1899 the percentage of purchased electric power has been

YEARLY OUTPUT
METROPOLITAN DISTRICT
(Greater New York and Public Service Co. of New Jersey)

Companies.	1921
New York Edison and Allied Companies	1,270,000,000 Kw. Hrs.
Brooklyn Edison Company	440,000,000 " "
Public Service Corporation of New Jersey	567,000,000 " "
Total Light and Power	2,277,000,000 " "
Interborn Rapid Transit Company	520,000,000 " "
Brooklyn Rapid Tymsit Company	270,000,000 " "
Public Service Corporation of New Jersey	243,000,000 " "
Edison and United Companies	140,000,000 " "
Total Street Railway Companies	1,283,000,000 " "
New York Central Railroad Company	166,000,000 " "
Pennsylvania Railroad Company	230,000,000 " "
N.Y., N.H., & H. Railroad Company	80,000,000 " "
Total Railroad Companies	426,000,000 " "
Grand Total	4,006,000,000 " "

PLATE 21

progressively greater than the percentage increase of power produced in the manufacturing establishments. Between 1914 and 1919 these percentages were 140 per cent and 9 per

Output and Horsepower Hours
Electric Lighting and Power Companies, and Transportation Companies
in Greater New York and Metropolitan District
1922.

	Electric Light and Power Companies.	Transportation Companies.	Totals.
Maximum Loads on Generating Stations	720,000-	480,000	1,200,000 Kilowatts
Output of Generating Stations	2,280,000,000-	1,670,000,000	3,950,000,000 Kw. Hrs.

PLATE 22

cent, respectively. The actual increase in horsepower of purchased energy was 3½ times that of power produced by the industries, pointing to a rapid diminution of power produced in manufacturing establishments, except under exceptional conditions.

From Plate 21 and Plate 19 it will be seen that the outputs of the generating stations for the New York-New Jersey Metropolitan District amounted to about four and one-third billion kilowatt hours in 1921. In 1922, slide 22, the New York Metropolitan District alone showed a generating station output of nearly four billion kilowatt hours, as seen in Plate 19, with a maximum load on the stations of about 1,200,000 kilowatts. Every

electric system serving a large center of population is confronted by some such problem as this, and the question

PLATE 23

arises: shall we continue to extend our steam generating stations, adding new ones as loads grow, or shall we turn to other sources of power? It may be of some interest to examine in this connection possible sources of hydro-electric power that may be made available in the New York Metropolitan District, the Delaware, upper Hudson and Central New York, Niagara and the St. Lawrence.

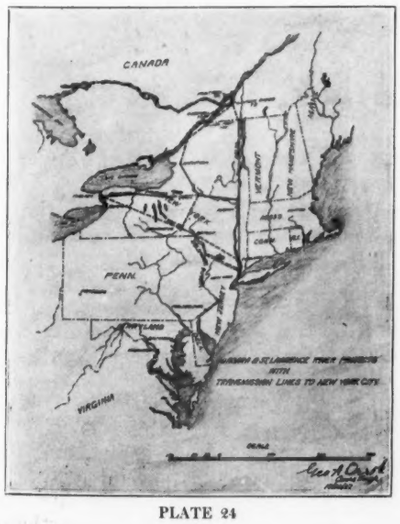


PLATE 24

The next slide shows you what we mean when we speak of the power plants in the metropolitan area. We mean all of the plants in Brooklyn and Queens, New York and the Bronx, Yonkers and Westchester County, all of it up to the Putnam County Line and up to the Connecticut Line. All of these plants except the Brooklyn plant, which, however, is tied in with them, are operated under a single control as one system, so we have there within the limits of the franchises of the companies a very complete super-power system development. This heavy line, I may say, is the line of the Catskill Aqueduct on which there is a 40,000-volt transmission line, overhead, of course, and that is the backbone from which high tension lines feed to the right and to the left.

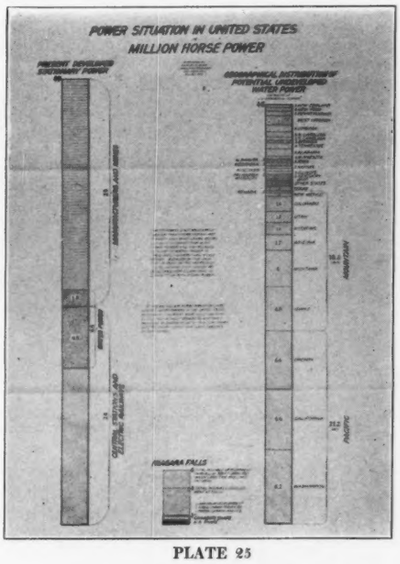


PLATE 25

In Plate 25 we have the relation of the metropolitan area and I must apologize for not having put on there the New England situation — but you see here that in New York or at Peekskill we are about equidistant from Niagara Falls and from the St. Lawrence, the St. Lawrence area being that in which Mr. Aldred, the founder of this course of lectures, has done such marvelous work in developing the Canadian water power resources.

It has not been possible within the limits of one address to touch upon many of the commercial and administrative problems with which the furnishing of electricity supply to a great city must concern itself.

With the generation of the current at the busbars we are merely at the threshold of the undertaking, and the many steps involved in the transmission and distribution of the current and its delivery to the customers' premises, the satisfying of the service conditions, regulation of the pressure, and metering of the product — all these come within the engineering or technical phases of the enterprise.

We have then not even entered the realm of the business or commercial branches of the undertaking and the administrative steps involved in marketing the product, in finding new applications for the output of electrical energy, collecting the revenue, accounting for the receipts and expenditures, formulating the rate schedules, and the maintenance of happy relations with the employees engaged in the various departments of the organization. All of these should receive consideration.

In no type of industry is the maintenance of the best industrial and labor relations of such paramount importance to the success of the enterprise as in the central station industry, where faithfulness in the service and loyalty to the company of every single man is absolutely essential to success, with perfect team work and singleness of purpose in every department. In a service where the carelessness or inattention of a single employee in any one of the operating branches may cause a complete shut-down, with incalculable consequences to life and property, and with the many employees whose daily contact with the public and attitude of courtesy and desire to serve the public are of the essentials in creating good will for the corporation — its most valuable business asset — it is of the utmost consequence that there shall exist the best of feeling toward the management and a high *esprit de corps* among the employees.

These industrial or human relations are coming to be appreciated more and more at their just value. The engineer will do well to cultivate a proper attitude toward these problems and to inform himself as to the psychology and conditions of operation of what we may call — without thought of measuring the human spirit with a foot-rule — the human machine as distinguished from a unit of mechanical equipment. The personal touch with his men, the human attitude toward the great sociological problems of the day, a sympathetic attitude toward the other fellow's point of view, will go far toward making the engineer popular with his men and securing their enthusiastic coöperation.

Conclusion

The central station industry in its relations to the problems of urban and suburban development presents many interesting phases calling for diversified knowledge in the fields of the civil, mechanical and electrical engineer. The public utilities have become absolutely essential to the life and welfare of the community, and they afford a splendid field for the display of these most essential qualifications

(*Continued on page 281*)

CURIOUS ADVENTURES OF A TECH GRADUATE

By WILLIAM E. NICKERSON,'76
Director of the Gillette Safety Razor Company

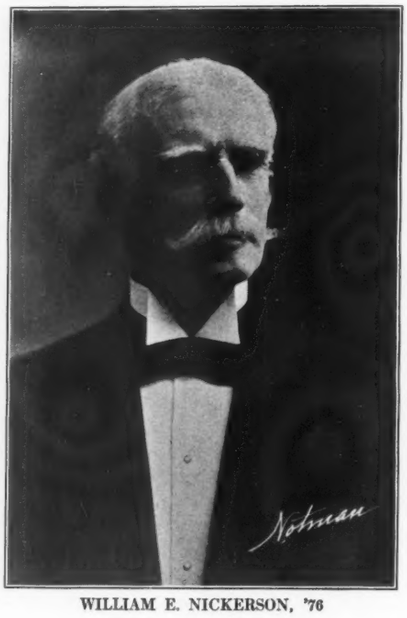
I STAND before you at the request of Mr. Aldred, whose wise liberality has provided for the appearance before you of men who have been through the mill of practical life, the object being to enlarge the contact of those within the walls of the college and those who are working in similar fields outside; in other words, a contact between the so-called academic and the so-called practical. This seems to me to be a very desirable thing. I well remember with what feelings of confidence and respect I listened to the professors of my own student days, who had had work to do in the active world, in addition to their college duties.

When Mr. Aldred told me that he wished me to appear before you, I was much surprised, not to say shocked. I reminded him that I was in no way qualified for such a task, that I knew nothing whatever that this meeting would care to hear, that I would not be able to pass the entrance examinations to Tech. (But I have heard that few college presidents would be able to enter their own institutions.) Much less would I be able to tell the senior class anything worth while. This recalls the saying that you can always tell a Harvard student; but that you cannot tell him *much!* I see no reason to assume that this applies to Tech students and, as a matter of fact, I think it is not quite just to "Fair Harvard." Neither could I charm my hearers by telling them next to nothing in a very impressive way or in a pleasing manner. Nor has my voice that soothing quality characteristic of polished public speakers. I once talked into a recording phonograph and heard it talk back to me, and I will never do it again. I shall do well if I am able to escape a critical summary, similar to that given by the old Scotchwoman when asked by the new "meenister" how she liked his sermon. "In the first place, ye read it; ye did na read it weel; an' it were na' worth the reading."

In spite of what I told him, Mr. Aldred persisted. He said that my experiences in life were of such a nature as to be of interest to young men about to start out on professional or scientific careers. Well, perhaps so. I may at least pose as an example not to be followed, and draw your attention to a multitude of things that should *not* be done.

I will be frank enough to say that I do not wish you to take me too seriously, and I shall try to see to it that you do not. That would be an error that I seek to avoid myself; and I think I succeed fairly well. There is, however, I hope and believe, at least one lesson that a young man might learn from my experiences. What that lesson is I shall enlarge upon toward the end of my remarks.

From what I have said, you have probably surmised that all I can



WILLIAM E. NICKERSON, '76

give you is a sort of biographical summary, with its high lights and deep shadows. If that is what you now expect, you may, perhaps, not be wholly disappointed. Other speakers in this course will take you into their laboratories, or their engineering offices, and give you glimpses of columns of figures, statistics, new methods, new products, and such like. This I cannot do. So if you are not able to learn something from the personal side of my life, my talk will certainly be like the new "meenister's" sermon before referred to. At any rate, I have given my discourse the title of "The Curious Adventures of an Old Tech Graduate."

I was born on the tip of Cape Cod. The high school from which I graduated stood precisely on the spot now occupied by the Pilgrim Monument. During my boyhood I showed an unmistakable mechanical bent. I delighted in building boats, bird houses, sleds and many other things. Among my books was a school astronomy, a broad thin book like a geography. It had many star maps and pictures of the solar system and of the individual planets. The text was arranged in the form of questions and answers. The solar system appealed to my mechanical instincts, the star maps interested me less. By the time I was twelve years old I had the solar system well fixed in my mind, with the diameters of the planets, their distances from the sun, times of revolution and rotation, attractive force at their surface, physical characteristics, etc. Further than this, I had a very definite idea of how the system looked and a multitude of facts connected with it. These pictures and most of the facts have remained with me to this day, and they have been the source of much pleasure through life. This grasping of so intricate a mechanical problem indicates the type of mind I had as a boy. Later experiences have given these things a certain significance. On the other hand, and very unfortunately, I had no particular love for mathematics, with the possible exception of those parts of plane and solid geometry which I was able to grasp in a mechanical way, like the proposition that all the angles of any triangle are equal to two right angles, the areas of numerous figures and the cubical contents of various geometrically-shaped bodies, etc.

I have mentioned the above facts in order to show that one's natural bent is always struggling to find expression, and he is fortunate who can ascertain what his bent really is, and then find a way to develop it. I do not mean by this that one should pursue only those subjects for which one is particularly adapted. This would be a serious mistake, for such a course is likely to result in a very one-sided development. It stimulates already dominant faculties and neglects those which especially need cultivation, if a well-rounded activity and character are to be secured. I would say if you have a study which you hate, but which you know to be of value, master it at all costs. I realized too late how much I have missed by not doing this. To master a subject which you dislike, and for which you have no special qualification, is a triumph of scholarship. It hardens the mental fiber; it strengthens the will and that power of sustained mental concentration which is one of the characteristics of great minds. To do some work which is distasteful

and irksome is really necessary, if one is to be prepared to face the difficulties of life and overcome them. Kindergarten methods, in which the pupil is to learn with the least possible mental effort, are fit only for young children and entirely unworthy of the serious student of riper years. This idea might be pushed too far. So far that we should work at disagreeable tasks only. But this is not likely to happen very often, for the natural impulses are all against it. Of course we should try to give our natural talents free play and make the most of them, but we should not fail to remedy our deficiencies and develop our weak sides. Further than this, we shall live longer and get more out of life, for ourselves and for others, if we have some "hobbies," some objects of interest which are far removed from the daily grind of our lives. If these things are of a constructive nature, very well, but have them anyway, no matter what others may think about it.

When I was about twelve years old another book came into my possession. It was an old school chemistry, compiled by Grund, whoever he may have been. I got much interested in it and was very desirous to try for myself the experiments described therein. The chemicals at my service were few in number, and of course I had no apparatus, excepting such as I could improvise myself. Perhaps it was just as well, for if I could have put my hands on anything I thought I wanted, I might not be before you today. However, such experiments as I could perform I worked to the limit, and really learned quite a little. Some effects I produced were rather out of order, as for instance, when I collected marsh gas in tin cans by stirring up the mud in the bottom of a pond and then blowing myself up in various ways with that inflammable substance, and by going to sleep with a small bottle of concentrated nitric acid and a cork stopper in my vest pocket. These last mentioned experiments made a powerful impression on me, literally as well as figuratively, and the memory of them is still vivid. My dabbling in chemistry convinced me, at the age of twelve or thirteen, that I wanted to be a chemist. And here again I think it was the fascination of the apparatus, rather than the chemistry proper, that captured my imagination by its appeal to my mechanical sense. But a chemist I was going to be, and for some years I tried to carry out that idea. I will, however, confess to you that, as I see it now, I never was a real chemist. I only thought I was. Industrial chemistry, as it then was, appealed to me strongly, but organic chemistry, a real test, I never sincerely loved.

Referring again to "hobbies," in my boyhood I had three which were outside those things in which boys are usually interested: astronomy, chemistry and the tying of knots. As I have indicated, I lived in a seaport town, and I became deeply interested in splicing and knot tying. Every kind of a knot, every kind of a splice, and much ornamental fancy work, I learned; everything of the kind that sailors and riggers could show me, and that I could get from a book called the "Sheet Anchor." That might look like a waste of time for a landsman. As a matter of fact, I have constantly made use of this knowledge, most of which still abides with me, and it has often helped me out of a tight place.

Yes, I believe in hobbies as offsets to the strains and fatigues of professional and business life. Since middle life I have given much time and thought to the higher forms of music; not as a performer, but as a listener and reader. I believe this form of recreation is well worth the attention of any busy man of affairs. Very likely some of my hearers may be thinking that I am making a hobby of hobbies. Perhaps I am, but I could easily give you much worse advice than my recommendation to pursue one or two good ones. If an idealist needs some contact with hard matters of fact to keep his head below the clouds so that he may see where he really is, so a practical scientist, or professional or business man needs an artistic outlook of some kind to lift his vision at times above and away from the world of rigid facts, in order that his mind and character may be rounded out and not become one-sided and narrow. James Russell Lowell said: "I shall never be persuaded that Shakespeare did not leave humanity as valuable a legacy as Watt." Probably most of us would hardly be able to agree with Lowell in his comparison of Watt and Shakespeare. It looks like going a little too far. But the position might be taken that if Watt had not invented the steam engine, some one else would have done so, while Shakespeare's immortal works could have been produced by none but he.

One morning in the latter part of September, 1870, I mounted the granite steps of the old Rogers Building on Boylston Street and became a student at the Massachusetts Institute of Technology. When we remember that the first class to graduate was that of 1868, it becomes apparent that Massachusetts Institute of Technology was then a very young institution. It had, however, achieved a very good reputation, and stood well up in the group among which were the Lawrence, the Sheffield, Cornell and Johns Hopkins.

In 1870, and for some years thereafter, the Rogers Building housed all the activities of the Institute, and the various departments were compactly distributed within the walls. The relatively small number of students and the limited amount of equipment made this possible.

My preparation for the Institute had not been very thorough, especially in the matter of scholarly discipline, and I failed to realize that much hard work was necessary to make a good record as a scholar. On this account, my standing as a student was quite moderate. In fact, I employed the kindergarten method much more than I should have done, putting my efforts into the studies that I liked, and avoiding more or less those that did not appeal to me. This was all wrong, and I have paid the penalty for it, in various ways. I was connected with the Institute for six years, part of the time as a regular student, and part as a "special." For several years I served as assistant in the general laboratory for inorganic chemistry and qualitative analysis, and also as private assistant to the late Professor Nichols, in his work for the State of Massachusetts, in the field of sanitary chemistry.

Finally in 1876 I took all lacking examinations and graduated in the Department of Chemistry. So it will be seen that I was still laboring under the delusion that I was a real chemist, and that my future activities were to be in that field. The one interesting thing about my graduation was the following: If I had been a real chemist I would have gone to the professor of organic chemistry and have asked him to recommend for my graduating thesis some research work in the organic field. In that case I probably would have succeeded in producing (with his assistance) some new substitution product, having a name consisting of a procession of chemical syllables, a certain specific gravity and boiling point and perhaps an intolerably villainous smell. Such a thesis would at least have lent some dignity to the chemical end of the graduating class, and would have justified me in carrying my chin a little higher for a month or so. Then the neat little thesis would probably have been folded away and an appropriate inscription would have been "rest in peace."

But instead of doing that, I went to the professor of industrial chemistry, and he suggested that I should work upon the determination of tannic acid, as applied to the valuation of

tanning materials, in relation to the tanning of leather. This suggestion I adopted to the utter disgust of the professor of organic chemistry. I know he never forgave me for it, and it has always been a mystery to me how I got my degree at all. I must have had some good friends in the faculty of that day. Well, anyway, that mongrel, low grade thesis got me my first job, for it was seen by a gentleman who was at the same time a large tanner, a bank president in Boston, and a trustee of the Institute. He had it published in the *Shoe and Leather Reporter*, and the outcome was that I was engaged by an association of tanning firms, organized for the purpose, and I spent a year or two in showing them how to save money in the handling of their bark and other tanning materials. One of the brightest and most progressive of these tanners afterward told me that the money he had spent on my work was the most profitable investment he ever made. As long as I remained in the chemical field I had occasional calls to serve one or another of these tanners in the valuation of their tanning materials or spent bark. So from the practical side, my poor thesis did not do so badly.

While engaged in the work for the tanners, I made a discovery related to tanning, and by adding a little invention, evolved a combination of patentable nature. This I disclosed to one of the tanners, with whom I had become especially friendly. Three months afterward the friendly tanner showed me an issued patent on my invention, taken out in his own name. He explained to me that it would not make any difference in whose name the patent stood, for if any money was made out of it, he would divide it with me. As no money was made out of it, his word was never put to the test. This recalls a case described in "The Autocrat of The Breakfast Table," where Holmes said that he wrote a convivial poem for a certain occasion. The poem was then much mutilated by the gentleman in charge, who had strong prohibition sentiments. Holmes was advised by a friend to charge double for the hurt to his feelings. He said that he did so, but as the bill was never paid it did not make *much* difference. The lesson to be learned from my experience with my tanner friend seems to be that it is not always well to tell all you know, especially to the wrong party.

The time had now arrived when my natural bent was beginning to encroach upon the field of my training. Hemlock and oak barks were then the principal substances used in tanning, and were ground in rather crude cast iron mills, working somewhat on the same principle as an ordinary coffee grinder. This sort of grinding left much of the bark in pieces, varying in size from that of a pea bean, to that of a Lima bean. Bark fragments as coarse as this retained, after leaching, a large part of their soluble tanning material, sometimes as much as fifty per cent. This I soon discovered, and realizing that a new method of grinding was necessary, if bark was to be thoroughly leached. I invented a new bark cutter. It consisted of a large number of thick saws, of slightly different diameters and thickness, all arranged on a strong arbor or shaft, with feed rolls and other accessories. This machine proved, when properly built, to be an unqualified success from a theoretical, and also from a mechanical point of view. It actually reduced the bark to sawdust, thus rendering almost complete extraction of the soluble tanning material an easy matter. So far so good! But the tanners were very conservative people and did not get excited about it, and I was attacked by a company which claimed infringement of one of their patents. So, as I lacked money and experience, I accepted an offer, to turn my invention over to the suing company. The terms of the offer did not bind the company to do anything in particular, so they shelved my invention, and I had spent my money and time for the privilege of learning that the tree of invention was not bending with ripe fruit, all ready to be picked. Strange to say, however, I had contracted the invention habit, and I had the same lesson taught me several times, in after years. I could tell you many amusing things connected with the building and testing of my bark cutter, my first experiences with the United States Patent Office, the machine draftsman, the pattern shop, the foundry, the machine shop, etc. However, I scraped acquaintance with all these people and things, an acquaintance that was to become much more intimate, as the years rolled on. It is easy to see, however, that every step I took in the direction of mechanics was away from the profession I had chosen. If a man be *sufficiently* versatile and industrious, he may shine in several diverse callings, but the average man is not likely to do so.

After my engagement with the tanners had come to an end, I spent a few months in Europe, and on my return built a one-story brick laboratory in Somerville, where I then lived, and started in to apply my moderate knowledge of chemistry to business purposes. That was in 1880. At this point I recall that it cost $2.50 per thousand to lay bricks. A mason laid 1,500 per day and could on occasion lay 2,500 in ten hours. I understand that now 500 bricks is the limit allowed for one day and that agitation is going on to reduce it to 400. The cost is from $25 to $35 per thousand, yet many people wonder why rents are so high. I did quite a little assaying for different people, and investigated an antimony mine located in Maine. I then took up the refining of jewelers' waste for gold and silver. I soon tired of this latter work, for no matter how conscientious I was, my patrons always looked suspicious and I revolted against it. It is not pleasant to be engaged in an occupation, in which you cannot prove your honesty at any time.

Now came an importer of aniline dyes who wanted a chemist to test his wares for color and economy and then go to the mills and convince the dyers that his were the goods they should buy. I took this up with enthusiasm, and soon became acquainted with a long list of aniline violets, blues, yellows, browns, pinks, reds and what not, made by the Actien-Gesellschaft of Berlin. I made trips to various woolen and cotton mills throughout New England and interviewed the dyers. Instead, however, of convincing the dyers that they needed my dyes, they and my laboratory tests gradually convinced me that my competitors were giving them more for the money than I could possibly do. In addition to this, I found that many dyers expected something on the side which I could not and would not give, and further, that I was no salesman anyway and would not be able to sell a gold dollar for more than eighty cents. I admire a good salesman and have often wished I was more of one myself. The most remarkable man in that line that I recall was the one who, after upsetting a cup of coffee on the white flannel trousers of his neighbor, talked so persuasively that the victim not only excused the ruin of his trousers, but offered to pay for the spilled coffee.

I was now near the end of my career as a chemist, although at the time I did not know it. It was not much of a career at best, but I had done some hard work and had sincerely tried to accomplish something. It may be noted that I had persistently stuck to the idea of running my own business, and this same notion has followed me most of my life. Had I entered the service of some corporation, as many graduates in chemistry do, I might perhaps have done much better. But whether, in such a case, I would have remained a routine analyst or something of that sort,

all my life, or would have emerged from the level into something higher, I, of course, do not know. If any lesson can be learned from my work as a chemist, I think it is this: work for somebody else until you have accumulated enough practical knowledge of the world and its ways to know what you are about before you go into business for yourself.

It must not be assumed, from what I have said, that I have ever regretted studying at the Massachusetts Institute of Technology. On the contrary, I have always looked upon my student days with great pleasure, and have remembered the cheerful side of my experience there, rather than the gloomy one. I really took away with me a large amount of valuable information, much of which has been of use in solving the problems which have been presented to me, and nearly all of which has helped to broaden my knowledge and appreciation, not only of the natural world, but of life itself. Had I taken the course in physics, or of mechanical engineering, it might have been more in keeping with such natural talents as I had, but I have wasted no time in vain regrets, for there is no evidence to show that I should have succeeded any better. It takes both effort and judgment to succeed in any path. I have never spared the effort, but have often been lacking in good judgment.

I would like to advise young men who lack a keen sense of humor to cultivate that mental trait. The disagreeable things in life will claim your attention sufficiently. To see and appreciate the humorous side will lighten many tasks and make advancing years rest more easily upon you. A still more important admonition in this: never, if it can be avoided, make an important decision while angry, or while chafing under a feeling of real or fancied injustice or wrong. Such decisions are usually bad, and are likely to prove very expensive and sometimes disastrous. I have learned this from repeated experiences. Make your important decisions deliberately, with coolness, and with due knowledge of all the facts. It will save you many regrets and humiliations.

But to return to my story. Just as I had become convinced of the futility of my efforts in the dye trade, an intimate friend of mine, a former Tech student, made a short visit to Boston, from the gold belt of Northern Georgia, where he was superintending an alleged gold mine. There is much gold in that part of the South, but it is too thinly scattered to have ever paid for the investment of much capital. I have just used the word "futility." The teacher asked a boy what the word meant. The boy said he could not define it exactly, but an example would be trying to tickle a turtle's back with a chicken feather. This would fairly well illustrate my attempts to sell dyes. My friend's account of the country and his work excited my interest and on his return South I accompanied him on a tour of inspection. I panned gold in the river gravel, got the gold fever, and spent five years in Georgia, first in gold mining and then in lumber, operating a saw mill and afterward a planing mill. I put in a large amount of hard work and brought home in 1886 a good deal of experience, much of which was valuable. But I brought back no money. In fact, quite the contrary.

Now the lesson which I should have learned from my southern experience was about this: not to go headlong into any important thing without having thoroughly investigated it, so as to be able to proceed in a reasonably sure way to a successful issue. I did not learn this lesson as I should, for I have made the same mistake more than once since then. I think I have at last learned it, but it took a long time to do it, and I have paid a good round penalty for not having learned it earlier. Optimism and enthusiasm are good things, and great works are seldom accomplished without them, but they are very unsafe unless they are counterbalanced by prudence and sound judgment. By all means cultivate optimism and enthusiasm, but remember that they are a team liable to run away with you at any time, and when this happens you are due for a smashup when obstructions are encountered. If you have good reasons to know that you are somewhat lacking in the instincts of the trader and the financier, you will do well to discuss your business affairs with one or more friends who are thus endowed. It is well to remember when dealing with the average financier or business man that he is likely to have views very similar to a certain little girl at a party where apples were being passed around. One apple was particularly fine and several children modestly resisted the temptation to take it. Finally one yielded and took it. The next in turn, with anger and disappointment showing in her face, exclaimed: "How selfish of you to take the biggest apple on the plate. I was just going to take it myself." If you are naturally generous and yielding, you should make extra effort to protect your rights and make the most of your opportunities, curbing your over-generous impulses until the time comes when you can properly give them a freer rein. Nothing can be more creditable than liberal use of honestly earned wealth, but it is best to wait until it is yours to give. I am punctuating my story with what I consider to be the lessons I have learned in the hard school of experience. The story is of little consequence, but the lessons ought to be of some value if they are heeded.

After my return from the South I engaged in various rather unimportant activities for a while, trying to discover some new avenue which might lead to business success. At this point an elevator fell in Boston and several people were killed. Presto! I would invent some kind of safety device that would prevent such accidents. It will be noted that I seized upon the mechanical opportunity that thus presented itself, but never once thought of returning to chemical work. This shows that chemistry in any form had wholly lost its appeal. It may also be noted that I clung to playing a lone hand whether I won or lost, and that working for others was, for some reason, contrary to my feelings. I have heard it said that there could be no such thing as an Irish band, for the Irish were so independent that each member would be bound to play a tune of his own. I may have been blessed with something of the same spirit. I hired a room on Sudbury Street and worked for three years on all sorts of inventions relating to elevators. Some of my inventions had merit, especially those relating to the selective electrical control of elevators for different floors, and those pertaining to the automatic interlocking of the doors of the elevator well and the car. I have lived to see them all used, but I was in advance of the times. I got into pretty deep water in the elevator work and contracted debts that for me were heavy. Just as I had got to the point where I did not know what to do next, an avenue of escape opened up.

A certain man had built a vacuum pump with the idea of exhausting incandescent lamp bulbs without the use of mercury. He had put a great deal of work into polished surfaces and close fits, but had not discovered the correct principle, and the pump would not do the work. He was at the end of his rope, for his backers would go no further on his judgment or promises. I was recommended as a possible solution of the *impasse!* Hydraulics and pneumatics have always been more or less easy for me, that is, in a mechanical way, and I had not worked very long with the pump inventor before I struck the secret of success, and we soon had the pump remodeled and improved to such an extent as to produce a vacuum fine enough for lamp work. We expected to sell or

lease the invention to the then big lamp companies. But they would have none of it, and it was decided to organize and go into the lamp-making business. We named the lamp the "Beacon," and for two or three years we made money. The Company's stock, of which I owned some, took on a value and I had my first taste of real prosperity. You may be sure I enjoyed it to the limit, and proceeded as if I were dipping meal out of an inexhaustible meal tub. Then the Edison Company, finding we were getting dangerous, sued us for infringing their patent claim on the all-glass globe with the hermetically sealed leading-in-wires. Then, soon after, crash! The court decided we were infringing and issued a permanent injunction. My stock had been worth over sixty thousand dollars, but after that injunction it was worth about sixty cents. I hustled around and contrived a so-called "plugged" lamp, the only practicable one ever made. Edison once testified in court that a successful plugged lamp could not be made. But I made one. This we manufactured and marketed for a year and a half, at which time the Edison patent expired, and that company reduced the price of lamps below the cost of manufacture, and, in fact, gave them away to those who used their current. Thus ended my brief prosperity born of the vacuum pump inventions, and I must start anew in something else. I had had some fun out of it, I had paid off my old debts, enjoyed the prosperity while it lasted and made some valuable acquaintances. I ought to have saved some money while the opportunity was present, but I did not, for the collapse of the stock value was so sudden that there was no chance to cash in. I paid the usual penalty for not being thrifty and long-headed. But I was ready to begin all over again, and there was some virtue in that.

I was now forty-three years old an age at which most people who are popularly considered successful are either firmly established in life or are well on the way to that very satisfactory condition, an age which the very young man feels is the beginning of the end. I had been planning and toiling and losing out for twenty years, since I had graduated from Tech in 1876. All I had to show for these twenty years of work and worry was considerable experience of a very varied nature, a little of this and a little of that, but no money and no settled position or prospect. I had also formed some friendships, a number of which proved to be useful as well as enduring. As I look back upon those days I wonder that I did not feel fearful and despondent. But not so. Any new effort looked just as hopeful as if I had never made a mistake or a failure. I may say here that my failures were mostly on the business side of my ventures. When I was a young man a copy of O. S. Fowler's Phrenology fell into my hands. His plea for the truth of that alleged science won my adherence and I had my head gone over by many different members of the profession. The last chart I secured was made by Nelson Sizer in 1887 when I was thirty-four years old. He was the successor of Fowler and had been a pupil and *protégé* of that great apostle of the art or science, whichever it was. Sizer then had quarters on Broadway, New York, near Fourteenth Street. When I entered Mr. Sizer's audience room, I had my head entirely covered with a very large handkerchief. I could dimly see through the meshes of the cloth the astonished look on the face of Mr. Sizer whom I then saw for the first time, as he asked me why I had covered up my head. I explained that I was a strong believer in the substantial truth of phrenology, but that I was aware that there was also a science of physiognomy and I wanted a straight phrenological chart, uninfluenced by any other condition. He laughed and said it was quite immaterial to him. I afterward thought that he might have worked up caution on this incident alone; perhaps he did. I think I interested him. I had certainly put him on his mettle and he was an expert. He gave a wonderful reading of my mental traits and with all the years that have passed since then, I am not able to criticise his delineation. At the time I disputed his rating on acquisitiveness. "Why," I said, "you have given me next to the highest in acquisitiveness and I have not been able to keep a dollar and I am afraid I never shall be able to keep one." "Ah," said he, "why dollars only? How about other things?" Then I had to admit that I had held on tenaciously to everything else and was still in possession of about all the old junk that had ever come into my hands and I have not got over the weakness yet. But the part of his reading to which I want to call particular attention was his assertion that I had a very large share of what he called whalebone and rubber. He said if I were bent I would come back with a snap. It is possible that my experiences in life justify his description. I hope that not many of this Senior class will have as much need of "whalebone and rubber" as I did. But I also hope that those who do need it will find that they have a sufficient quantity stowed away somewhere, "between decks," as it were.

"The path of success in business is generally the path of common sense. Notwithstanding all that is said about 'lucky hits,' the best kind of success, in every man's life, is not that which is brought about by accident. The only 'good time coming' we are justified in hoping for is that which we are capable of making for ourselves. It is not good for human nature to have the road of life made too easy. It may, indeed, be questioned whether a heavier curse could be imposed on man than the complete gratification of all his wishes, without effort on his part, leaving nothing for his hopes, desires or struggles. Those who fail in life are very apt to assume the tone of injured innocence, and conclude too hastily that everybody excepting themselves has had a hand in their personal misfortune; but it will generally be found that men who are constantly lamenting their ill luck are only reaping the consequence of their own neglect, mismanagement and improvidence." "Attention, application, accuracy, method, punctuality, and despatch are the principal qualities required for the efficient conduct of business of any sort. Nothing begets confidence in a man sooner than the practice of punctuality, and nothing shakes confidence sooner than the want of it. It will generally be found that the men who are habitually behind time are habitually behind success, and that they become grumblers and railers against fortune." "Great virtues are rare; the occasions for them are rare; and, when they do occur, we are prepared for them; we are excited by the grandeur of the sacrifice; we are supported either by the splendor of the deed in the eyes of the world, or by the self-complacency that we experienced from the performance of the uncommon action. Little things are unforeseen; they return every moment; they come in contact with our pride, our indolence, our haughtiness, our readiness to take offence; they contradict our inclinations perpetually. It is, however, only by fidelity in little things that a true and constant love can be distinguished from a passing fervor of spirit."

To return to my story! A short time before the affairs of the Lamp Company had reached so unsatisfactory a stage as to cause my withdrawal from it, I became interested in a machine for the automatic weighing of various commodities. When the final separation came, I entered with my usual enthusiasm into the new project. The weighing machine referred to was the invention of a friend of mine. It was ingenious but crude. I designed another which I thought to be better. My friend

and I joined interests. He felt he could not afford to spend much money on it and he was quite justified in feeling that way about it. I, however, went at it, hammer and tongs, contrived a piece of apparatus that operated commercially, incorporated a company, held fifty-one per cent of the stock and was all set — for trouble. My friend got a cash offer for his interest and wisely took it. Capital was necessary, so I began to let my shares get away from me. After a while I had but a few left, although I had designed and built a great quantity of weighing apparatus adapted for various purposes. I became a mere employee of the Company, for combinations and changes of personnel had taken place, the control passing into the hands of strangers who cared very little about my welfare. Finally the whole enterprise was transported to New Jersey. I had named the company the "New England." New Yorkers could not stand that, so they rechristened it "Automatic." For about two years I spent one day each week at the New Jersey factory and incidentally two nights a week on a sleeping car on the New York - Boston route, in consideration of which I received about half a living compensation. About the time the Weighing Machine Company moved to New Jersey and I was again "crawling out of the little end of the horn," another new proposition was placed before me. As that was twenty-two years ago and as I am still connected with the proposition and have recently passed my seventieth birthday, and further, as the proposition has been more or less of a success, it is quite probable that it is the ultimate and final one which I shall have to consider in the way of business. The proposition to which I refer was the development and manufacture of the Gillette Safety Razor, which was then in embryo form and mostly theoretical. But the theory was sound and had occupied much of Mr. Gillette's thought for five or six years.

About one year before I became interested in the Gillette razor, I saw a model of it at the house of a friend in Brookline. It did not look to me like a practical thing and, in truth, the invention was very far from having reached a practical stage. I did not give the subject much thought at the time, for the model shown failed to arouse my interest. Later, Mr. Gillette put the razor into the hands of a gentleman with whom I had been associated in the lamp company, eight or ten years before. I wish to say at this place that Mr. Gillette had a very clever idea when he thought of trying to make a razor blade so cheaply as to warrant throwing it away when dull. I much doubt if any man ever dreamed of that before he did. When I first met Mr. Gillette in 1901, he hoped that it would be possible to sell blades for one cent each and he expected them to shave but once. We have never met these conditions in terms. Any blade that would yield but one shave would not be likely to give much comfort to the user even for that single application. But we have done better, in a way, than Mr. Gillette hoped, for we have made the blade cost the general public less than one cent per shave and for many discreet users the cost is very much less than that.

In the spring of 1901 the gentleman who was promoting the razor came to me and said he believed that I could make a success of it if I would only try. I told him I knew nothing about razors or any other sort of cutlery and did not feel any particular interest in the scheme. But he was not making any progress in his efforts to get a razor that would actually shave and such blades as he had succeeded in getting made would have sold under cost if they had brought five dollars apiece, so he came to me with the same request several times. Well, I was nearly forty-eight years old and had still nothing on hand that was either promising or encouraging. So finally I told him that I would take the matter in hand and give it some serious thought and that I would give him an answer in a month. At the end of the month my answer was in the affirmative. In the meantime, I had studied the situation and had come to the conclusion that the thing could be done and I felt quite confident that I could do it. I understood perfectly well that Mr. Gillette had made a very remarkable invention and had carried it much farther than a business man could reasonably be expected to do. What was needed now was more or less scientific treatment and the application of practical mechanical knowledge such as I had accumulated in my varied career. There was also need of a large amount of new and original work and invention in the manufacture of the razor, and that I hoped to be able to supply.

During my month of investigation I ascertained that some of the razor experts in Boston, who had been shown the Gillette model, had made light of it and had declared with great positiveness that the whole scheme was wholly visionary, that honing and stropping razor edges was necessarily a hand operation and could not possibly be done by machinery. They also declared that thin steel could not be adapted to the successful production of fine edges and would not take the proper temper for anything so delicate as a razor edge. The opinions of the experts did not discourage me, however, for I had in my past experience been able to do several things which experts had thought to be impracticable or even impossible. But somebody is always doing the supposably impossible. If they were not, human progress would be much slower than it has been.

About the first of September, 1901, I made a beginning in the solution of the Gillette problem. I first determined the shape that I wanted the blade to take. That shape has never been changed and today it is a familiar one all over the world. I decided that the width of the blade ought to be $\frac{7}{8}$ of an inch, for $\frac{3}{4}$ of an inch seemed to me to be too narrow for easy flexing and one inch was apparently unnecessarily wide. Seven-eighths appealed to me as being just about right and over twenty years experience in manufacture and use has confirmed the accuracy of my first guess in this important particular. Having decided the question of width I next determined the length of the cutting edges. In this matter I borrowed from the experience of my predecessors in the art. I found the old "Star" razor, as well as its imitator the old "Gem," used an edge $1\frac{1}{2}$ inches long. I accepted their experience as my guide and made no mistake in so doing. Now came the disposition of the perforations in the blade. One in the center for the clamping pin was evidently necessary, as that gave little trouble. In the old model that was handed me for inspection the blade was about 12/1000 thick and $\frac{5}{8}$ of an inch wide. It had square ends with a notch or recess in each to engage a small tongue or projection on the holder to keep the blade in position. I had looked far enough ahead in the manufacture and use of the blade to know that the notches should be exchanged for sizable perforations, so as to facilitate stacking the blades upon pins and for other purposes in manufacturing, as well as for the accurate location of the blade in the shaving holder. As soon as the manufacture of blades was attempted, it became apparent to all concerned that no mistake had been made here. Now the shape of the ends of the blade must be determined. This I accomplished by drawing two parallel lines $\frac{7}{8}$ of an inch apart (the width of the blade) and then drawing a circle with its center midway between the two lines and of such a diameter that the two parallel lines acting as chords had a length of $1\frac{1}{2}$ inches each (the desired length of the edges). This gives the figure of the

Gillette blade, familiar to at least one half of the world's human inhabitants. A blade has over twenty-five million users and of which our company is making over three hundred million in 1923. Rounding the ends of the blade accomplished several things. It strengthened the blade against cracking along the longitudinal center line; it furnished a portion to grasp by nippers or otherwise during manufacture and provided a pleasing and characteristic contour amounting to a trade mark. There are hundreds of millions of people who, if shown the outline of our blade, would know it as that of a Gillette Razor Blade. This would not be true of a less characteristic shape, so that it has great commercial value.

My first choice for the thickness of the blade was 6/1000 of an inch and this was before I had tried to make any. I afterward experimented with thicknesses from 3/1000 to 12/1000 but 6/1000 was found best and has always been used commercially. The variation in thickness is kept pretty well within ¼/1000 plus or minus. Our specifications for blade steel are very rigid and have been the despair of a number of steel makers. I do not want to be too boastful, but I think you will have to admit that I really did some pretty good guessing for a beginner in the razor art.

After deciding upon the size and form of the blade I turned to the holder. The "Star" and the "Gem" were then about the only safety or guard razors used to any extent. They were alike, excepting in a few details. The blades were, as I have stated, 1½ inches long. They had a cross-section identical with that of an ordinary "hollow-ground" barber's razor and retailed for $1.25 each. They had to be honed and stropped like ordinary razors and special handles were furnished for that purpose. The holders themselves were stamped up from sheet brass of about 24 gauge, or somewhat under $\frac{1}{32}$ of an inch thick. No serious attempt seems to have been made to get a very accurate relationship between the blade edge and the guard. There was protection enough from the guard to prevent the cutting off of one's nose, but not enough to avoid an occasional bad slicing of the face, especially on the more angular portions. The accuracy then attained was about as great as that sort of construction could be expected to give. As soon as I began to study the holder, I grasped the idea that what was needed to get the best results was a type of holder that would admit of being made very accurately, and that would maintain that accuracy in use. The ideal that I then had in mind was not fully reached until our "New Improved" Gillette was put on the market some two years ago. I wanted what I called a "machined" holder, in contradistinction to one stamped up out of relatively thin sheet metal. As far as I know, I was the first worker in the field who grasped the full importance of an accurate holder, one of real precision, right down to the thousandth of an inch. This was the idea I had in mind and I did what I could to give that idea expression.

I wish to return for a moment to Mr. Gillette's invention. I do not think it at all likely that a man possessing enough mechanical experience to have been able to develop the Gillette idea would have ever thought of the scheme. It seemed to be such an unreasonable thing that almost everybody laughed at it. It was contrary to all theory and practice. Yet Mr. Gillette did think of it and persisted in his more or less blind faith for five or six years. The more glory to him. He made a great invention, an invention which has revolutionized an art and has set the pace for all contemporary razor makers ever since the "Gillette Razor" has been on the market. Having done this it would not have been fair to him to have expected that he should also furnish the thousand and one details that were necessary to bring his idea to fruition. But, per contra, what an exacting and nerve-racking piece of work he turned over to me, when I undertook to put flesh and blood, so to speak, upon the visionary creature his imagination had conjured up. The task was one of great difficulty and complexity, but hopeful perseverance and hard work won in the end, and the great Gillette enterprise of today stands as a memorial, first to Mr. Gillette whose brilliant invention laid the foundation, and next to the scores of persevering, painstaking and loyal servants of the company among whom I am still able to claim a humble position.

After I had decided upon the exact form of the blade and holder, I went to work upon sharpening machinery and hardening apparatus. These took some months to design and build and were quite new in their way. While this work was going on, several of us who were interested found enough persons who were willing to gamble on the razor and my efforts to bring it out, to put up $250 each and so raised $5,000, to pay for development work and my wages of $40 per week for half time, the other half belonging to the Weighing Machine Company. Out of twenty people who put up their $250, not more than four kept the five hundred shares of stock which they received long enough to get the big prize. They got "cold feet," so-called, when unfavorable rumors were circulated just before the enterprise began its upward journey. They all got from four to six times what they put in, but they missed the main chance, for the equivalent of that five hundred shares would sell today for nearly $400,000 and has paid in dividends, cash and stock about as much more. Of course those who sold too soon have had many regrets and in some cases have complained bitterly.

After the first experimental equipment was completed the effort to make holders and blades began. My troubles also began and multiplied. Many difficulties presented themselves and some of them seemed almost insurmountable. Hard work and perseverance prevailed and at the end of about one year I had made machine sharpened blades and holders to use them in, which shaved well enough to prove that we were not chasing a will-o-the-wisp, but had in hand the beginning of a real business, that only needed further development to expand into a success of great proportions.

One of the remarkable things about the Gillette enterprise is the fact, that the original $5,000 that was raised in twenty contributions of $250 each was the only money that was ever permanently invested in the business. All other money for starting the business, amounting to about $60,000, was borrowed on bonds with a stock bonus and was returned to the lender a short time after we got fairly started on our business career. Of the enormously valuable assets of the Company today, every penny has been earned and I believe that I am well within the truth when I say that the Company has given the public full value, and more, for all the money which that public has paid it, for those who have used our razor with intelligence have certainly got more than their money's worth.

From the summer of 1902 to January, 1904, we went on with the work of turning the experimental affair of making a few razors and blades that would really shave into the business proposition of actually putting satisfactory goods on the market at a profit. Those were heart-breaking, nerve-racking times and I found it necessary not only to keep up my own courage, but to furnish considerable more for the use of those who were less hopeful and were impatiently waiting for the desired point to be reached. Shakespeare made one of his characters say: "Receive what cheer you may. The night is long that never finds the day." Our night ended at last and the day came, but even the day had

plenty of problems and troubles. I found need, not only of any natural mechanical aptitude which nature had furnished me, but of all the long experience which my series of successes and failures had given me. While I was often exasperated and wearied, I did not falter or lose courage but plodded steadily onward. I am thankful that I did, and so, doubtless, are many others.

It was not very long, after the razor went on the market, until we were obliged to run nights to keep up with orders. There was once a popular song that began, "A little green peach in an orchard grew; and it grew; and it grew; and it grew." Well, that was what the Gillette enterprise did. Now that I am on that subject I may add, it is still growing, and I have not the least idea when it is going to stop growing. Nothing in sight indicates such a thing, for we shall sell over seven million razors and over twenty-five million dozen blades this year.

The original machinery such as we used up to about 1913 has nearly all been replaced by later automatic types. With our present output, if we were still using our old equipment, we should need ten or twelve thousand employees instead of the two thousand which we now require. And so the march of improvement and efficiency goes on. Our plant represents an investment in land, buildings and equipment of nearly $8,000,000, and we are continually outgrowing it. Our tangible assets are approaching $35,000,000, but our record has been so good, our present position so strong, and our future so promising, that the general public believe that the ultimate value of our Company is far in excess of that shown by its tangible assets alone. This accounts for the price which the stock brings in the market today. Whatever of prosperity we have, the results are divided among many people, for we have four thousand stockholders and two thousand employees. We further contribute to the gains of tens of thousands of dealers and lastly, to the convenience, health and economy, of millions and millions of patrons, scattered all over the world. Up to September, 1917, we had certainly been doing very well, but on that date, Mr. Aldred, through whose courtesy I am before you, reorganized our company financially, and by reason of that reorganization our progress has become so much accelerated that we ourselves often gasp with astonishment at what takes place. A brilliant essayist has said: "As the dimensions of the tree are not always regulated by the size of the seed, so the consequences of things are not always proportionate to the apparent magnitude of those events that have produced them." If ever this was true of anything it is true of the Gillette enterprise.

I have now reached a point where I desire to drive home one of the most important lessons that a man can learn. I refer to the superlative importance of keeping cool and thinking clearly, uninfluenced by passion, or by personal loves or hates, when the important affairs of life are under consideration. I will give you an illustration. In 1905 when the Gillette Company had gotten well under way, but had not, as yet, arrived at a point where everyone might see that it was to be a great success, I was in possession of a large number of shares of its stock. Part of this had come to me from the Company, as a reward for my work, and part of it I had bought from others, with money borrowed from a bank. Just at this time, as often happens in building enterprises, there arose a clash of ambitions and interests. The events that took place caused me to feel that I was not being used just right, and that my interests were in danger. I made, I am ashamed to say, a rather feeble attempt to improve my position, and then in a moment of chagrin and despair, of anger and wounded feelings, I sold my stock for a song, to one who was very glad to buy it. I was fifty-two years old and ought to have known better. If I had kept my head cool, swallowed my feelings, and used a fair amount of good hard sense, I would not have done such a foolish thing, and would have saved myself many regrets and humiliations. So after thirty years of struggle, and at the very threshold of a success beyond any reasonable expectation, I threw away my hard-earned reward. Within five years the stock that I had sold for almost nothing would have made me, had I kept it, a multi-millionaire. I saw the company grow and prosper, year after year, and I had no part in it, except a lot of worry and hard work, plus a very moderate salary and some disappointing perquisites. This went on for twelve years. In 1917, however, at the age of sixty-four, through the good offices and liberality of some of my associates, my title to a greater participation in the prosperity of our company was recognized. Today there is nothing that I could reasonably desire to change in my relations with the company, and I am very happy in all my business associations. No longer ago than the fifth of last month, which happened to be my seventieth birthday, I received a very beautiful sterling silver pitcher, bearing an inscription which conveyed to me the "love and esteem" of my Gillette associates. What more could anyone desire? But back to the lesson. Please observe how, by my own fault and weakness, I lost my proper reward for my work. Also observe how near I came to losing even the benefits which I have lately enjoyed by my connection with the company. These I would also have lost, if I had not persistently stuck to my work. Now once more observe how easy it is to destroy the results of years of effort by the hasty, ill-considered and especially the angry decision of vital matters. I hope you will take this lesson to heart. It may mean much to you. To quote Cowper:

"Beware of desperate steps; the darkest day,
Live till to-morrow will have passed away."

"The Precepts of Ptah Hotep," which are among the oldest known Egyptian writings, dating back to 2500 B.C., contain the following:

"If thou desirest that thy conduct should be good and preserved from evil, keep thyself from every attack of bad humor. It is a fatal malady and leads to discord; it embodies all kinds of wrong." It was true then and it is true now. But whatever you do, heed this: "Waste not fresh tears over old griefs." A thought expressed by Euripides, 480 B.C. Within the last few years a number of men have come to me ostensibly for advice, but I saw it was for sympathy with which to sooth their wounded feelings. A humorous philosopher has said: "Pity don't cost nothin', and taint wuth nothin'." Self-pity is absolutely a vice, or a malady, just as you please. By talking with these applicants, I have persuaded every one of them to cool their heads instead of their heels, and keep their jobs.

To what I have just said I would add that it seems to me very desirable for the young man to learn to get along with people whose personalities do not exactly please him. It is inevitable that every man in active life will be brought in contact with many who irritate him and try his patience and even his temper. He cannot make them over, and he will often lose advantages if he fails to use tact in his dealings with them. Speaking of tact, it is one of the greatest of human qualities. It has been contrasted with talent by a brilliant writer as follows:

"Talent is something, tact is everything. It is not a sixth sense, it is the life of all five. It is the open eye, the quick ear, the judging taste, the keen smell, the lively touch. It is the interpreter of all riddles, the surmounter of all difficulties, the remover

of all obstacles. It is useful in all places and at all times. Talent is power, tact is skill, talent is weight, tact is momentum, talent knows what to do, tact knows how to do it, talent is wealth, tact is ready money. For all the practical purposes of life, tact carries it against talent, ten to one."

I will add to this: What a terrible misfit everywhere is a tactless person! In heaven's name, cultivate tact!

I often have occasion, when signing my name, to state my occupation. On account of my varied career, I sometimes find this rather difficult. I ceased to be a chemist many years ago, so that is out of the question! If I sign "director," it is not very definite. Most of our directors only spend an hour with us once a month, and some are worse than that. I object to "inventor," because I have known so many that claimed the title whom it makes me somewhat sick to even think about. And yet we should not be too hard on the poor inventor, for we owe all we have in the material life to him, excepting only our naked bodies and wild nature, and no small part of our moral and spiritual makeup to boot. I feel that I am more than a mere machine designer, so that is unsatisfactory. Sometimes in desperation I call myself "consulting engineer." But that is not quite true. If it were now, as in the olden times, I might pluck up courage and call myself "gentleman." But that will not do, for "gentlemen" are out of date. So about all I can do is to console myself with the thought, that I have had a hand in one good success and may let titles go begging.

Sometimes when I have accompanied visitors through the Gillette plant, they have become somewhat sentimental and have said when looking at some of the machines of my design: "My, but you must have lain awake a great many nights thinking out such complicated things." Nothing could be further from the truth. I do not do my work that way. If I had, I doubt if I should have celebrated my seventieth birthday. From long experience, I have accumulated in my mind the qualities of most of the fundamental mechanical ideas, and when I want to design a machine I first get clearly in my mind what it is that I want to make, and then shuffle the elementary mechanical elements into place as a good cook would make a birthday cake. Why there is absolutely nothing to it, that is, when you have had practice enough. If all the machines and appliances which I have contrived in the last fifty years were placed end to end, I am sure the line would more than reach from here to the State House on Beacon Hill. Although you may perhaps think so, I really am not boasting. Yet I am not particularly interested in mechanisms, outside those on which I may be at work. I have had enough. To ask me to cross the street to see some wonderful new machine would be much like asking a man who sawed wood for a living, to make a little sawdust for fun, on Thanksgiving Day, or Christmas. There are many things in the world that are of more interest to me.

I never expect to be much of a philosopher, but I do like to philosophize. A few years ago I went through all the plays of Shakespeare and culled out hundreds and hundreds of gems of thought, crystallized into such sparkling forms as only the great dramatist could produce. With what interest I did this, and what pleasure it afforded me, I cannot easily explain. I had one hundred of my selections printed on large cards, and in very coarse type. These I had framed. I have given many of them to friends. I have a number displayed in the Gillette offices, and many are over the doors of certain parts of my own home. While they only tell us what we already know, yet they are wonderful in the art involved, in their form and color. I love them, and they return my affection by preaching to me daily. Let me tell you of some which I have in my own chamber and hallway.

"He that loves to be flattered
Is worthy of the flatterer."

"Happy are they that hear their detractions
And can put them to mending."

"As surfeit is the father of much fast,
So every scope by the immoderate use,
Turns to restraint."

"There are more things in heaven and earth,
Than are dreamt of in your philosophy."

"Nothing, will come of nothing."

"Our remedies oft in ourselves do lie,
Which we ascribe to heaven: the fated sky
Gives us free scope; only doth backward pull
Our slow designs, when we ourselves are dull."

"My friends praise me, and make an ass of me;
Now my foes tell me plainly, I am an ass;
So that by my foes, sir, I profit in the knowledge
Of myself; and by my friends, I am abased."

"Love all, trust a few,
Do wrong to none; be able for thine enemy,
Rather in power than in use, and keep thy friend
Under thine own life's key; be checked for silence,
But never taxed for speech."

In the directors' room at the factory I hung up this one:

"If it were as easy to do, as to know what to do,
Chapels had been Churches and poor men's hovels Princes' Palaces."

I presume you see the appropriateness.

In the superintendent's office, where the foremen frequently meet, there are displayed:

"'Tis deeds must win the prize."

"To do this is within the compass of man's wit;
And therefore I will accept the doing of it."

"Why, now I see there's mettle in thee;
And, even from this instant, do build on thee,
A better opinion than ever before."

To these might be added:

"Thou art made if thou desirest to be so;
If not, let me see thee a steward still,
The fellow of servants, and not worthy
To touch fortune's fingers."

"Men at sometime are masters of their fate;
The fault — is not in our stars,
But in ourselves, that we are underlings."

"The fates open their hands;
Let thy blood and spirit embrace them."

There are those who can profit by these admonitions.

Perhaps some of my hearers may think: Oh, well, what has all this to do with a technical school? If so, please remember that I told you that I was not going to talk science, or engineering, but life. Now, in rebuttal of any such thought as I mentioned, let me suggest this: Suppose that all the engineers knew was engineering and all the lawyers knew was law, and all the physicians knew was medicine, and so on. In such a case, would not this be a stupid and intolerable world? Even the brightest people might then be compared to a diamond which had one or two facets polished, and all the others rough and dull. Not a pleasing gem. It would be a great thing if it were possible for

students to graduate from such institutions as Harvard before beginning their technical courses here. But I suppose that is not often practicable. It is practicable, however, and in every way desirable, for the scientific man to give enough time and thought to the various forms of art and literature, to be able to distinguish the true from the false and to round out his mentality. He will make just as good an engineer, or electrician, or chemist, and he will be a bigger man. He will get more out of life, and give more to the life of others. He will, as a light giver, be like the full moon, and not like the first or last quarter. And, after all, what are science, and industry, and commerce, and finance worth, beyond serving as supports for the intellectual life of the race? The material world is of little consequence to us, excepting as it ministers to our mental and spiritual life. I have never asked Mr. Aldred what he thinks about these things. He is an eminently successful man, a great organizer, a constructive genius, but I feel sure that he would agree with me in these matters. I know that in his own case, his mind reached out in many other directions than those involved in his financial affairs.

Young men, I am trying to spread before you the lessons learned in a long and active life, involving many failures and at least a few successes. I am also presenting you with some of the conclusions which have been forced upon me by my own experience and by my observation of others. Many of the things I am saying may seem to be merely truisms and quite axiomatic. But make no mistake; life is made up, principally, of truisms and axioms, if we have the wit to realize it! So you cannot afford to overlook them altogether. There is really nothing new under the sun, for it was always there whether we knew it or not. I shall now draw my remarks to a close as rapidly as possible.

Cultivate courage, tempered by discretion. That rustic New England philosopher, who wrote under the name of Josh Billings (whose wit and wisdom, by the way, I greatly admire and often quote) said:

"Courage without discreshun is like a ram with horns on both ends; he will have more fights on hand than he can do justice to."

It takes courage to win a hard fight.

"If thou faint in the day of adversity thy strength is small"; so says the Proverb.

"What, Courage man! What though care killed a cat,
Thou hast mettle enough in thee to kill care."

"Now I have taken heart, thou vanishest,
Ill spirit."

"Cowards die many times before their death;
The valiant never taste of death but once."

"No man can be brave who considers pain to be the greatest evil of life, nor temperate who considers pleasure to be the highest good." So said Cicero.

"Our doubts are traitors,
And make us lose the good we oft might win,
By fearing to attempt."

"Fortune is not on the side of the faint hearted." So said Sophocles B.C. 496.

"The gods always give little things to little folks." So said Horatius B.C. 65.

"A strong mind always hopes, and has always cause to hope."

"Get into the habit of looking for the silver lining of the clouds, rather than at the leaden gray in the middle. It will help you over many hard places."

"Who are the Murphys' ancestors?"
"What's that?" asked Mr. Murphy.
"From whom do the Murphys spring?"
"The Murphys spring *from* no wan, sor; they spring *at* him."

Treat obstacles in the same way.

Cultivate persistence, which, in some aspects, is quite distinct from courage. "The more powerful the obstacle, the more glory we have in overcoming it; and the difficulties with which we are met are the maids of honor which set off virtue." And now listen to Polybius 204 B.C. "For some men, like unskilled jockeys, give up their designs when they have almost reached the goal; while others, on the contrary, obtain a victory over their opponents, by exerting at the last moment, more vigorous efforts than ever before."

As a matter of course, cultivate industry. Said Shakespeare:
"A stirring dwarf we do allowance give
Before a sleeping giant."

Do not take too much offense at routine work. Listen to our Longfellow:

"The everyday cares and duties which men call drudgery are the weights and counterpoises of the clock of time, giving its pendulum a true vibration and its hands a regular motion."

Franklin said: "Industry need not wish, but he that lives upon hopes will die fasting." "Even the slow man, if possessed of wisdom, has overtaken the swift in the pursuit." So said Theognis (?) 570 B.C.

"Not to be whiled away in aimless dreams
But to improve ourselves and serve mankind
Life and its choicest faculties were given."

"Light services charm light minds," but not sound ones.

"The lazy die and are buried, and no man misses them; the workers live on in their work, and, in a true sense, possess the earth long after the earth holds their lifeless clay. Their monuments are around us, and above us, and we honor them for their work's sake, whether we will or not. 'Heaven helps those who help themselves,' is a well-worn maxim, embodying in a small compass the results of vast human experience."

Censure plays a large part in our lives, both for good and for evil. We blame others, and are blamed in turn. What attitude should we take in regard to it? Shakespeare says: "Take each man's censure, but reserve thy judgment." As a general rule, subject to some exceptions, it works well; there is no doubt about that. Swift said, "Censure is a tax a man pays for being eminent." Well, we have to pay taxes enough nowadays, so perhaps one or two more would not make much difference. We are bound to pay anyway. We are certain to shoulder more or less undeserved blame.

"No might or greatness in mortality
Can censure 'scape; back-wounding calumny
The whitest virtue strikes. What king so strong
Can tie the gall up in a slanderous tongue?"

Josh Billings says: "The more rare a man's qualities are, the more he will be found fault with; dust on a diamond iz alwas more noticeable than dust on a brik."

Josh also said that "If yu would eskape envy, abuse and taxes, you must live in a deep well, and only come out in the nite time." I would say, find as little fault with others as you can conveniently, and so not feel too badly if others criticise you, for your best friends will sometimes do it. "If the coat fits, put it on"; if not, throw it on the rubbish pile. It is, however, well to remember, that "Few persons have sufficient wisdom to prefer Censure which is useful to them, to Praise which deceives them." And "it is much easier to be critical than to be correct."

It is well to be consistent, but one should be careful not to overdo it. A slavish adherence to the notion cripples our faculties and often prevents the admission of new light. This reminds me of a man who had testified, inadvertently of course, that a certain man was eleven feet, five inches high. When reminded of what he had said, he reflected a while and then declared, "Well, if I said so I'll stick to it." Then on the other hand there are people that are so inconsistent and generally lacking in the firmer qualities, that, as our friend Josh says, "They have so little bakbone that yu kant help them; yu mite as well undertake to stand an angle worm up on end, and ask him to dance a jig."

As for vanity, egotism, boastfulness, pretension and selfishness, we need a little of each. We would not be natural, and hardly human, without any. But they ought to be in about the proportion that salt, pepper and other condiments are used in food. Just enough to give us a little flavor and prevent us from being flat. Per contra, what is harder to get along with, than what is known as "swelled head"? It seems almost to be a disease. Some who have an attack of it in youth recover. In others it becomes chronic, and they are very apt to be a heavy trial all their lives to their associates. It is an ailment to be dreaded, and I hope most of you young gentlemen will escape it. But I would advise consultation with some eminent authority at the first appearance of unfavorable symptoms. Shakespeare says:

"Conceit in weakest bodies strongest works."

The Malays have a proverb like this: "A sea turtle lays eggs by the hundred, and nobody knows anything about it; a hen lays one egg, and the noise goes all over town." Our friend Josh, who, after Shakespeare, knew how to say things about as well as anybody, says: "When a man gits tew talking about himself he seldum fails tew be eloquent, and frequently reaches the sublime." "The extreme pleasure we take in talking about ourselves should make us fear that we give very little to those who listen to us." Josh further says: "There is no real kure for vanity, but gitten thoroly wet cums the nearest, for the time being." Under the head of pretension, it is sufficient to note that "we are never made so ridiculous by the qualities we have as by those we pretend to have."

In all seriousness, beware of envy. It is a very common feeling, and often reaches the intensity of a passion. "Jealousy is, in some respects, just and reasonable, since its object is only to preserve a good which belongs, or which we think belongs, to us; whereas envy is a madness which cannot bear the good of others."

"The benevolent have the advantage of the envious, for the envious are tormented, not only by all the ills that befall themselves, but by all the good that happens to others."

"Envy, the meanest of vices, does not enter the minds of the noble, but creeps on the ground, like a hidden serpent."

Acquisition of worldly goods is a good thing, if we do not pay too high a price.

"To catch dame fortune's golden smile,
Assiduous wait upon her;
An' gather wealth by every wile
That's justified by honor;
Not for to hide it in a hedge,
Nor for a train attendant,
But for the glorious privilege
Of being independent."

It is sometimes easier to make money than it is to keep it, or to make the best use of it when it has been acquired. Money has a great tendency to slip through the fingers.

"Tell me," said the foreign sociologist, "what is the significance of the eagle that is shown on American money?" "It is," replied the Son of Liberty, "an emblem of its swift flight." "We ought to act toward fortune as we do with health; enjoy it when it is good, be patient when it is bad, and never apply violent remedies unless it is absolutely necessary." We should remember this: "There are no chances so unlucky, from which clever people are not able to reap some advantage, and none so lucky that the foolish are not able to turn them to their disadvantage."

There is a real joy in acts of creation, and many of you will experience this feeling in full measure, I have not the least doubt. The world is divided, in a way, into those who principally create, and those who mainly consume. This difference in function and attitude is neatly illustrated by these characteristic lines of Nietzsche: "Everyone who enjoys thinks that the principal thing to the tree is the fruit, but in point of fact the principal thing to it is the seed. Herein lies the difference between them that create and them that enjoy." But I suppose the world needs us all. If we were all creators there would doubtless be "overproduction."

We ought to be generous in our judgment and broad in our views, realizing that very often others may be nearer right than we are, and we should not fall into a narrowness and a provincialism like that of the old woman in the back woods who, when told by a New Yorker that he lived five hundred miles away, exclaimed, "O Lordy! I don't see how you can bear to live so far off."

Sociability, in a reasonable degree, is good for us. It should sweeten our disposition and keep our friendship in repair. Friends of the right kind are one of the great assets of life. They are necessary to the normal man to make life endurable, and even our material prosperity is often dependent upon their good offices. I despise a "toady," so-called, and it is not necessary for one to be servile, to have friends of importance, but it is well to choose our friends when possible from among those who are abler than ourselves. The ambitious small boy feels this, for he associates with the oldest boys who will tolerate him. An old writer advises, "Make not a bosom friend of a melancholy soul; he'll be sure to aggravate thy adversity and lessen thy prosperity. He goes heavily loaded; and thou must bear half." Sociability involves talking, but excessive loquacity is objectionable. Our friend Josh says: "There iz a time for all things, and the best time to hold our tongs iz when we feel az tho we had the most to say." "I prefer the gravity of the owl to the loquacity of the magpie; it is better to look wise than to talk foolish." "Nature has given us two ears and only one mouth."

"Nearly every one is looking for encouragement, but the most successful men have found it necessary to encourage themselves." "Fate leads the willing and drags the unwilling." Do not take the minor accidents of life too seriously but cultivate complacency. A man who fell down a flight of steps said it was all right; he was coming down anyway. Work willingly. Said Seneca: "He who willingly submits to another man's command has escaped from the most cruel part of servitude — that is to say, to do that which he is unwilling to do. The most miserable man is not he that has a command put upon him, but the man that does it against his will." Don't parade your sorrows but, as Josh says, "Bury them as dogs do their old bones, and then growl if any boddy offers to dig them up." Seize and hold your opportunities, for they, like birds, will slip out of your hands if you give them half a chance.

I like to see men take definite stands on subjects which are of legitimate interest to them. Those who try to straddle all questions do not usually command much respect. For such as these our old friend Josh has this satirical formula: "In shooting at a deer that looks like a calf, always aim so az tew miss it if it iz a calf, and to hit it if it iz a deer. In which case you will probably miss it anyway."

If you use your education well seasoned with common sense you will almost certainly attain to positions of great importance if not of eminence.

"The man who's in the rank and hews
All day to earn his bread,
Is there because he'd rather use
His arms than use his head."

Make a distinction between knowledge and wisdom, for you may have the one and not the other. It has been said that wisdom is the gift of God, but we should strive for it nevertheless. I think the young man is inclined to exalt knowledge over wisdom and the old man to do the reverse.

"Knowledge and Wisdom, far from being one,
Have ofttimes no connection. Knowledge dwells
In heads replete with thoughts of other men;
Wisdom, in minds attentive to their own.
Knowledge, — a rude, unprofitable mass,
The mere materials with which Wisdom builds.
Till smoothed, and squared, and fitted to its place —
Does but encumber whom it seems to enrich.
Knowledge is proud that he has learned so much;
Wisdom is humble that he knows no more."

Some of you will soon be out in the world looking for something that will advance you in life but not knowing exactly what it will be. You will then be somewhat in the position of the boy who was angling and was asked what he was fishing for. He replied "snigs." "What are snigs?" he was asked. "I don't know. I aint caught any yet." When you catch them, young gentlemen, I trust they will prove to be good sized fish!

In conclusion, allow me to call your attention to what should be expected of educated men like yourselves.

"Every liberally educated man ought to be a better man in his profession than if he were not thus educated. The man who has been liberally educated is prepared to liberalize and elevate any profession which it may be his lot to pursue. If there were nothing of the nature of liberal education in the community, the constant tendency of every profession, not excepting the learned professions, would be to sink into a mere trade. So every profession may be acquired and practiced as a mere trade; and on the other hand, any mechanical trade acquired and pursued by a man of well-informed and cultivated mind, bringing all his faculties to bear upon the proper business, becomes a liberal profession. One part, then, of the influence of the liberally educated man, in whatever employment, should be to bring into his profession large views of its relations to society and to the universal range of knowledge, and thus to counteract its tendency to mere technicality and unintelligent tradition.

DEVELOPMENT OF POWER IN A GREAT CITY

(*Continued from page 269*)

of the successful engineer — imagination and common sense; faculties complementary in a sense, yet at the antipodes of the scale in the mental attributes to which they make appeal.

Here we have a field presenting the most diversified applications of science to industry, the most interesting fusion of theory and practice, and ever changing, ever progressing development, combining the rigidity and power of inanimate mechanism with the subtle spirituality arising out of the human relations involved. Where can we find a greater joy of achievement, a nobler pride of professional attainment, a greater satisfaction, than in contributing to the public welfare by taking an active part in the solution of the problems of transportation, of generation of light and power, of the supply of essential public service, and in fighting the battle royal of the subjugation of the forces of nature for the convenience and happiness of mankind?

To the students of this Institute of Technology is presented an exceptional opportunity for the acquisition of engineering knowledge in many fields, the development of the proper mental attitude toward the investigation and analysis of the many economic problems which press for a solution, embued with that spirit of optimism and forward-looking vision that derives inspiration and cheer from the joy of accomplishment.

And thus may Technology continue in its splendid field of usefulness to industry and commerce, and in forwarding those ideals and high purposes which will secure for the professional engineer that measure of public appreciation to which his accomplishments in behalf of human progress and happiness so justly entitle him.

Gentlemen, I thank you for your kind attention. (Applause.)

Rubber Unsuccessful as Road Dressing in Ceylon. The experiments made in Ceylon by the firm of Gordon, Frazer & Co., for the use of rubber as a road surfacing material did not meet with the anticipated good results. The process consisted merely in the melting of scrap rubber, and the application of it, while hot, to the roads, it being spread in the same manner as a tar dressing. — *Rubber Age.*

What is the Record Non-Stop Engine Run? The remarkable performance of an engine over thirty years old makes it interesting to know whether a better record can be given, especially with an engine of more recent manufacture. The engine was manufactured in Leeds, England, and installed in New South Wales. It is of the compound self-condensing type of 250-i. h. p. Twenty years ago it had completed six years continuous run of twenty-four hours a day without a stop of any kind, totaling a distance of 2,198,760 miles, and was still going. — *Power.*

Air Cells in the ZR-1. The navy's latest masterpiece, the ZR-1, which has aroused nation-wide interest by its recent successful flights could have done little if anything had it not been for the rubber industry. The huge ship is kept afloat by eighteen air cells filled with helium. Eighteen other cells are kept in reserve. These cells are made of goldbeaters skin, the skin obtained from the big intestines of steers. It required more than 600,000 steers to furnish the necessary material.

Flywheel Breaks in Vernon, B. B. Steam Generating Plant. A curious accident happened at Vernon, B. C., recently, when the 20-ton flywheel of a steam engine of Swedish manufacture, at the city's electric generating plant, burst, doing considerable damage to the power house, but, fortunately, injuring no one. The two men were in the act of stopping the engine for the night when the accident occurred, one man being on either side of the wheel. The fragments of metal, some of which weighed several tons, flew off in a direct line to that in which the wheel was running, some going through the roof, some through the concrete walls.

Vernon has had considerable difficulty in keeping its streets and houses lighted since the accident. Among other devices, the city steam roller has been harnessed to one of the dynamos and has rendered valiant aid to the two 200 h. p. engines, which were uninjured. — *Power.*

MONTHLY NEWS

The Mercury Boiler and Turbine. Many of the difficulties incidental to the working out of a practicable mercury boiler and turbine have been overcome in the recent installation at the Dutch Point Station of the Hartford Electric Light Company.

The Hartford boiler is the fifteenth design to be constructed to date, the chief aim being to construct a boiler that does not require a prohibitive amount of mercury, will not overheat and will be free from excessive overstrains. Moreover, all joints must be welded to prevent the escape of mercury vapor and the ingress of air to the system, which would produce oxidation; and finally, the circulation must be such that all the liquid will immediately return to the boiler.

The process provides for the vaporization of mercury in the boiler at 35-lb. gage pressure and 812° F., expanding the mercury vapor through a turbine and utilizing the heat of the exhaust at 29-inch vacuum and 414° F. to generate steam, which is put through a separate turbine. That is, the mercury condenser surface is the steam boiler. In this way advantage is taken of a much greater temperature range than is possible with steam alone, and the thermal efficiency approximates that of the internal combustion engine; a kilowatt-hour at about 11,000 B.T.U.

Comparing the mercury vapor process with a steam-turbine generating plant running at 200-lb. steam pressure and with the highest standards of efficiency in turbines and auxiliaries, the mercury-steam combination running at 25-lb. gage gives about 52 per cent output in electricity per lb. of fuel. If the plant is arranged to burn 18 per cent more fuel, the station capacity with the same steam turbines and auxiliaries would be increased about 80 per cent.

The boiler is oil fired and the flue gases, after passing up through the mercury boiler, are led to a mercury heater or economizer, thence over the steam superheater to the feed-water heater and then to the stack. In this way the gases are brought to temperatures equivalent to those used in steam installations. The mercury boiler is of the vertical type, having a single tube sheet into which the tubes are expanded and then welded, leaving the lower ends free to expand. By this arrangement a maximum of heating surface is obtained with a minimum of mercury. The present boiler holds about 30,000 lbs. of mercury and is designed to evaporate 230,000 lbs. of mercury per hour. At this rate the turbine would develop 1,900 kw. and deliver about 28,000 lbs. of steam per hour at 200-lb. gage pressure and 100 degrees superheat.

In general design the mercury turbine is not unlike a steam turbine except that the blading is of tool steel to resist the cutting action of the mercury, and the glands are sealed with illuminating gas. When it is necessary to shut down the unit the illuminating gas is run into the system which prevents the ingress of air and so oxidation. — *Power.*

Transmission Line Over the Sierra Nevadas Completed. A 60,000-volt transmission line of considerable importance to the future development of California and Nevada was recently completed by the Truckee River Power Company. This line has the distinction of being at one of the highest altitudes in the State and is constructed to withstand the heavy storms that prevail during the winter season at the summit of the Sierra. The line ties to the Pacific Gas and Electric System at Summit Station on the line of the Southern Pacific Railway. It extends over the Sierra Divide at an elevation of 7,300 feet, skirting the range above Donner Lake till it reaches the Truckee Canyon. The line then goes down the Truckee River to the Washoe Plant where it is tied into the company's distribution system.

The capacity of this line is 7,500 kva., and it is estimated that this will supply the needs of the Reno and Virginia City districts for some time to come. Owing to the distance between the power station at Lake Spaulding and the point of distribution in Nevada, there is a considerable drop in voltage which will be taken care of by an automatic voltage regulator installed at the Washoe Plant. The distance between these two points is 50 miles, but the current is carried still farther into the mining districts so that a line potential of 63,000 volts is used to compensate for the line drop.

No. 2 stranded copper wire is used for the line strung on 70,000-volt pin-type insulators. The spans at the higher altitudes are 150 feet, while at the lower altitudes this is lengthened to 250 feet. The poles are of red cedar 45 feet long. — *Journal of Electricity.*

Railroads Pay Higher Wages Than Government. The average wages of railway employes are higher than the average of those paid to government employes. A study of the number and wages of all government employes in the United States — local, state and federal — recently made and published by the National Industrial Conference Board, shows that the average wage of government employes at the present time is $1,296 a year, while the average wage of railroad employes is $1,643 a year, or about 27 per cent more than that of government employes.

Records show that railroad employes have been paid higher wages in every year since the railways were returned to private operation than they were under government operation.

In 1918 the average railroad wage was $1,419 and in 1919, $1,485. These were the two years throughout which the railroads were operated by the government. In 1920 the average wage of railroad employes was $1,820; in 1921, $1,665, and in 1922, $1,630. In 1923 it was about $1,643.

World Production of Coal for Six Months Estimated. The Geological Survey has made a summary of the world production of coal for the first six months of 1923, which shows that 666,000,000 tons was mined during that time and indicates an increase of about 79,400,000 tons, or 13.3 per cent over the corresponding period of last year. All the countries listed, with the exception of Austria, Czechoslovakia and Germany, have increased their production. The most notable increases were in the United States, the United Kingdom and Poland.

—*Power.*

State of Texas Has Greatest Railroad Mileage. Records of the Interstate Commerce Commission show that the State of Texas, with 16,125 miles of railroad, has a greater railroad mileage than any other State in the country.

Flexible Rubber Wheels. An automobile wheel built of rubber and capable of distortion, flexible, resilient and upsetting all established wheel theory as regards rigid types of wheels is a recent development of the Sieberling Rubber Company.

It is prophesied that the new rubber wheel will remove the necessity for consideration of balloon tires. It distorts without structural injury, and has within itself the power that draws it back to its original shape. Being capable of distortion and resilient, it eliminated the need for snubbers and shock absorbers and is the answer to the added cushion sought in the development of the balloon tire. This rubber wheel has all the advantages of the accessories just named with none of their disadvantages. It uses standard size tires.

The structural backbone of the rubber wheel is a body of thin, porous wood and rubber plies amalgamated and interjoined into one unit. The process of amalgamation is one of interjoining and intertwining the wood and rubber and assures an inseparable union between the wood and rubber elements.

It is claimed that these wheels absorb shocks and transmit the force to the steering wheel as pulls rather than shocks. The wheel comes back to normal position evenly and quickly accentuating the self-aligning characteristics of present front wheel construction. Skidding is reduced to a minimum as the sudden pull is eliminated, which pull is the common cause of the tire losing its grip on the road. — *Rubber Age.*

Ethylene as an Anesthetic. It has been recently found that a mixture of ethylene and oxygen possesses marked analgesic and anesthetic properties, without giving rise to a sensation of asphyxia as is common with ether, but giving, on the contrary, a sense of well being and comfort.

During a clinical study in which 106 persons were anesthetized, the ethylene-oxygen mixture proved very satisfactory.

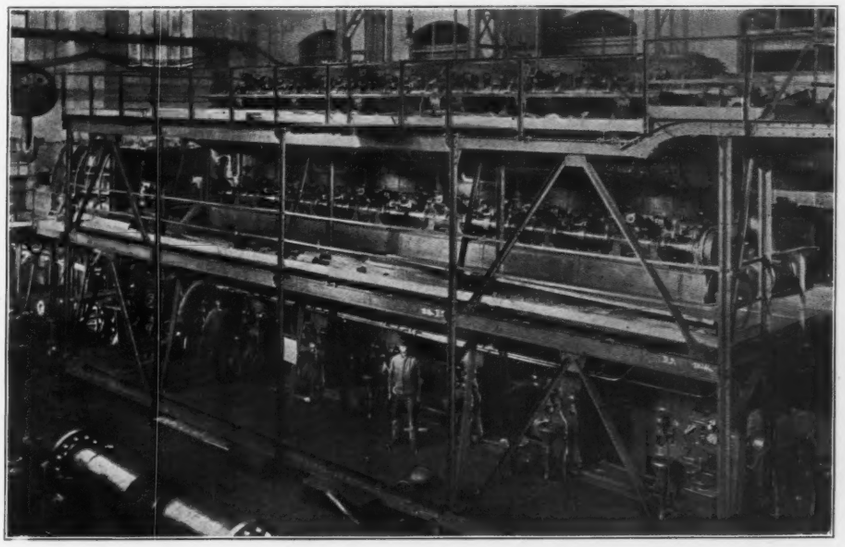
Since it is possible to administer with ethylene, on the average, as much as 16 to 18 per cent of oxygen asphyxia and its consequences are avoided. Also relaxation is more complete than with nitrous oxide and it is claimed that ethylene compares favorably with ether, as it possesses many of the advantages of ether without many of its troublesome after effects. The very prompt recovery points to a rapid elimination of ethylene, and may necessitate the administration of morphine immediately on the conclusion of the operation.

— *American Druggist.*

Twenty-Two Thousand-Volt Electric Steam Boiler. What is believed to be an absolutely unique installation was recently placed in operation by a large paper, pulp and chemical manufacturer. It is an electric boiler of 18,000 kilowatts rated capacity operating at 22,000 volts, three phase, 60-cycles, 135 lb. gage pressure, and producing 50,000 pounds of steam per hour. It displaces 69 tons of coal valued at $550 in 23 hours.

The boiler was installed for use only 23 hours on Sundays and other holidays when the mill is shut down with the exception of the sulphite digesters and other apparatus requiring steam every day.

The boiler consists of three vertical tanks, each 84 inches in diameter and 82 inches high between heads. It occupies a floor-space 25 feet, 6 inches long by 8 feet, 2 inches wide, and is 15 feet high from the floor to cable terminals. The cost of the installation was $25,000. In 46 days of 23-hour operation it will have returned its initial cost by the coal saved. —*Engineers and Engineering.*



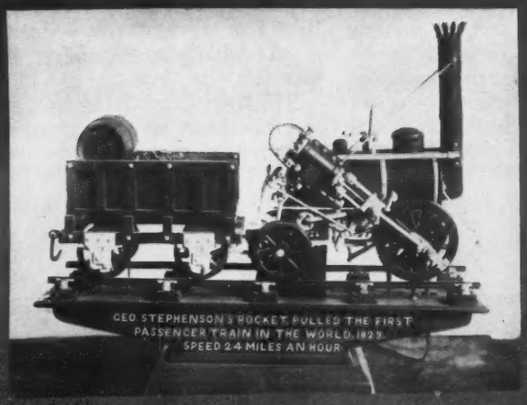
WORLD'S LARGEST DIESEL ENGINE
On test, it developed 17,150 shaft horse power

Canal Revenues Increased by California Oil. Owing to the development of California oil and its movement to the East Coast, the operations of the Panama Canal and auxiliary agencies during the fiscal year ended June 30, 1923, were record breaking in volume both as to financial returns to the United States Government and aid rendered to the shipping world. The annual report of Governor Morrow, made public November 18, shows that the canal netted a profit of $12,063,880 from all sources excluding the Panama Railroad Steamship Line, as compared with $9,201,613 in the fiscal year 1922. Traffic operations increased on a scale that has brought the waterway to a point rapidly overhauling the Suez Canal.

The net income from tolls and other miscellaneous receipts grouped under the head of transit revenue was $10,001,066, as compared with $3,466,674 in 1922. The net profits from auxiliary operations totaled $1,140,642, as against $323,259, while those conducted by the Panama Railroad Co., excluding the steamship operations, showed a profit of $922,171, against a loss of $710,301 in 1922. The report also showed that the number of commercial transits increased from 2,736, to 3,967, net tonnage from 11,417,459 to 18,605,786, tolls from $11,107,832 to $17,508,199 and cargo tonnage from 10,884,910 to 19,567,875.

Big New Mississippi Power Plant. A super-power steam plant to cost $10,000,000 and generating at least 200,000 h. p., where electricity will not only be manufactured for the consumption of the surrounding industrial community, but will be stepped up to 66,000 or 132,000 volts for long distance transmission, will be built on the banks of the Mississippi River near Davenport, Iowa.

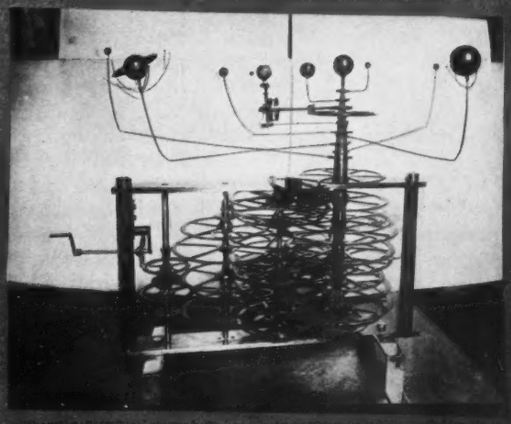
Shanghai Now One of Six Leading Ports. Although the world tonnage figures for the year 1922 are not yet available, it may be safely assumed that with a total tonnage of vessels entered and cleared in 1922 of 27.5 million tons, Shanghai now ranks amongst the six largest ports of the world.



The fastest locomotive in the world for the Paris-Orleans Railway. In its tests it made 99 miles per hour.
Wide World Photo.

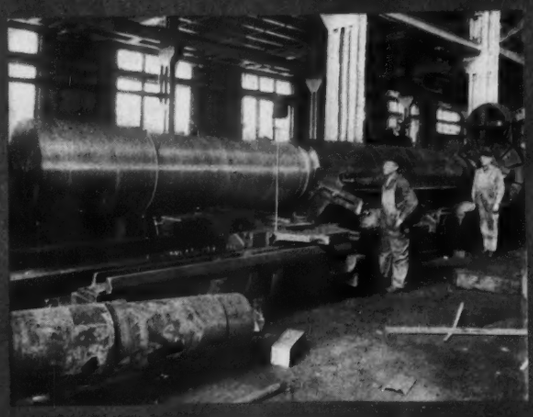
A comparison of the first and latest locomotives. Above is Stephenson's "Rocket" which pulled the first train at 24 miles per hour. Below is the newest product of the Pennsylvania Railroad, 45 per cent more powerful than the present Pacific type and weighing 544,000 pounds.
International Newsreel Photo.

The most powerful electric locomotive in the world designed for use in Mexico where it will pull freight trains up grades twice as steep as any in the United States.
Wide World Photo.



THE PLANETARY SYSTEM

This apparatus illustrates the rotations of the eight great planets around the sun.
Wide World Photo.

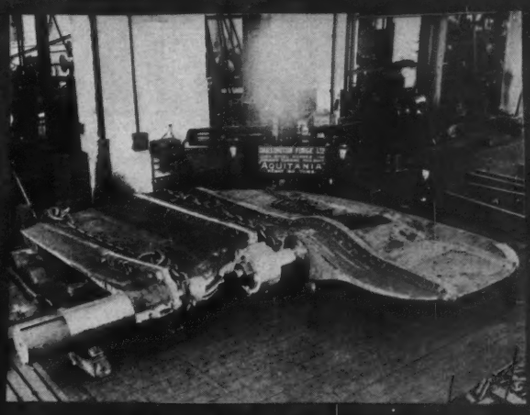


Machining a forty-ton shaft to within one one-thousandth of an inch.
International Newsreel Photo.

LIFTING FIFTEEN TONS WITH A SMALL STEEL BOTTLE

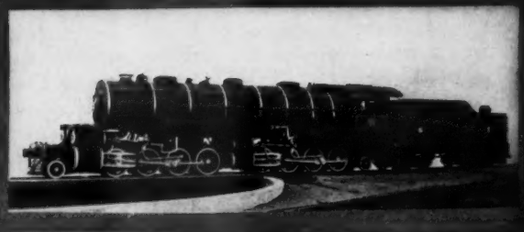
A recent invention will lift 30,000 pounds in three seconds. The power is derived from a small steel bottle containing a highly expansible liquid.

International Newsreel Photo.



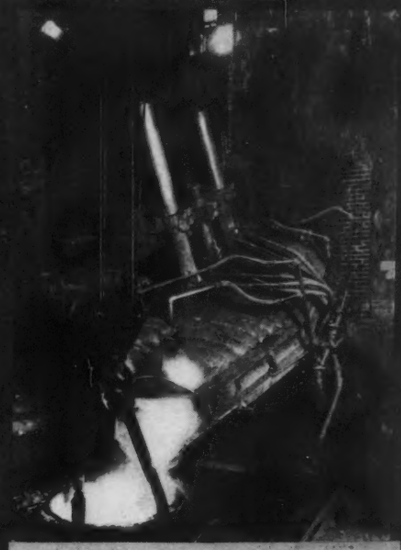
The rudder of the *Aquitania*, weighing eighty tons. It has a door in its side for inspection of the working parts.

International Newsreel Photo.



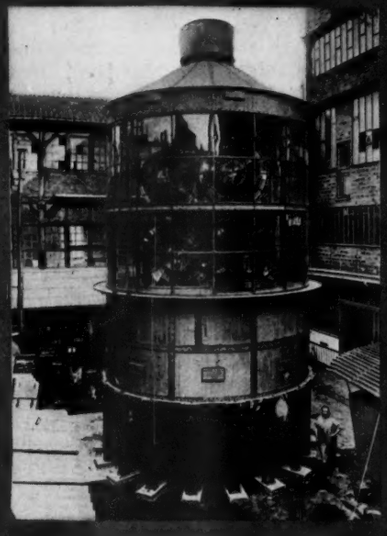
A three thousand horse power locomotive built for the Pekin-Suiyan Railway of China. It is 94 feet, 9 inches long and weighs 320 tons, and is said to be the largest locomotive ever shipped from the United States.

International Newsreel Photo.



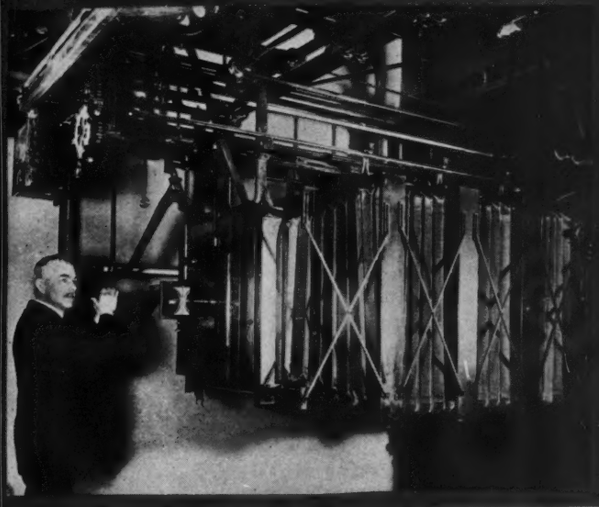
This giant melting pot holds three tons of molten metal. It requires 2700 kw., producing a temperature of 4200 degrees. This furnace could reduce five small automobiles to the fluidity of water in a single operation.

International Newsreel Photo.



This lighthouse is to be used to guide aviators in France. Eight arc lamps furnish a billion candle power.

Wide World Photo.



The three and one-half ton camera used by the United States Geological Survey, showing the bellows extension and the trackage required for carrying it.

Wide World Photo.

EDITORIALS

WHAT INDUSTRY EXPECTS

ALMOST every student of engineering intends to enter industry on the completion of his course. He has this goal tucked away back in his head and worries little about it. He does his tasks from day to day and rarely stops to think whether he is actually fitting himself to be of use to the industrial world. Perhaps this lack of foresight is due to ignorance on his part. How many students know what industry expects them to gain from their engineering education? It is safe to say that there are very few indeed.

A recent report of the National Industrial Conference Board tells very clearly just what industry expects that undergraduate to gain from his engineering course and is quoted here for his enlightenment, as follows: "The National Industrial Conference Board has received many valuable suggestions from prominent industrial and railroad executives and others whose views were solicited regarding possible improvements in the training which men receive from the engineering schools, and regarding a closer coöperative relationship between the engineering schools and American industry. The principal recommendations, coming from sixty-eight industrial executives, thirteen railroad executives, four engineers, three educators, one editor and six governmental officials, may be summarized as follows:

That the method of selecting men for admission to the colleges be improved;

That the students be trained broadly and thoroughly in the fundamentals;

That the colleges do more to stimulate initiative;

That the instructors in technical subjects have more practical experience, and be selected for vision and high ideals;

That the students be given practical training in industrial establishments either

(*a*) By serving an apprenticeship or in some other way, before entering college, or

(*b*) By industrial work during student's vacations, or

(*c*) By supplementary industrial training after completing the theoretical course, or

(*d*) By practical training in industry coincident with theoretical training in college, as in the coöperative courses at Cincinnati and elsewhere.

It is interesting to note that these various recommendations, based upon experience in many diversified interests apply broadly to the preparation for all branches of industry. All the industrialists are more interested in the general character and ability of their recruits than in the specific knowledge required in any particular industry. There is a general conviction that the methods of selecting recruits for engineering schools must be improved and that the courses of instruction should be in certain fundamentals rather than in specific technical information and should be planned to stimulate original thinking, initiative, vision and high ideals. The greatest unanimity is shown in the opinion that practical training in industrial establishments is essential for both instructors and students, and most of the writers believe that this industrial training of the students should be given before or during the college course.

In the suggestions brought forth by the inquiry above referred to, as well as in the meetings of the Advisory Conference Committee, much emphasis has been placed on the importance of adequate training in "fundamentals."

The fundamentals of engineering training may be stated as follows:

(*a*) Mathematics;

(*b*) The important principles of physics (mechanics, heat, light, sound, electricity, magnetism), chemistry, biology and geology, the interrelations of natural phenomena and the application of these principles to practical problems;

(*c*) The principles of economics and their application to industry and commerce;

(*d*) The principles that govern the relations between people, not only as applied to managers and men, but also as applied to governments and society;

(*e*) The history of nations;

(*f*) The art of clear and correct expression in speaking, writing and drawing.

The greatest need of industry is for high-grade men. Representatives of industry who visit the engineering schools in search of recruits invariably want the top men, but there are only a few to be had. The difficulty is that a large proportion of the graduates of the engineering schools each year are not of the right type for leading positions in industry, and many of these might have been better prepared for life in other ways.

This fact is well known to educators and is receiving much thought from them. Alone, however, they cannot solve the difficulty. College faculties can improve the tests for admission, but naturally their selections can be made only from the students who apply for admission. If the total number that come up to them from the preparatory schools is not large enough, they can do no more than take the best of those who present themselves. It should, however, be possible to reach back into the preparatory schools and begin the process of selection there to find the boys with the "science minds," who then may be guided towards the courses in engineering and applied sciences. Industrialists must, for their own benefit as well as that of the American youth, give very definite assistance to the educators in this matter.

Although there is room in industry for more graduates than the engineering schools are now turning out, it is more important that a greater proportion of these young men be of high quality than that the total number be increased. Accordingly, requirements for admission should be such as to place a premium on intelligence, self-mastery, resourcefulness, courage, vision, openmindedness, patience, persistence, critical judgment, integrity, and other elements of character as well as the pre-requisite to the college courses.

Limitation of the undergraduate courses to the thorough education in the fundamentals and employment of students in industrial pursuits during the undergraduate period will afford time and develop the basis for a progressive and, in the end, more effective determination of the life work of the student, which is now done largely in a more haphazard way and principally in the last period of undergraduate training."

—are you sure you deserve it?

"Give me a log with Mark Hopkins at one end of it and myself at the other," said, in effect, President Garfield, "and I would not want a better college."

But if Mark Hopkins was an inspired teacher, it is just as true that James A. Garfield was an inspiring student.

Sometimes Garfield's praise of his professor is quoted in disparagement of present day faculties —the assumption being that we as listeners are sympathetic, all that we ought to be—and that it is the teacher who has lost his vision.

Is this often the case?

It is the recollection of one graduate at least that he did not give his professors a chance. Cold to their enthusiasms, he was prone to regard those men more in the light of animated text-books than as human beings able and eager to expound their art or to go beyond it into the realm of his own personal problems.

This is a man to man proposition. Each has to go half way. Remember, there are two ends to the log.

Published in the interest of Electrical Development by an Institution that will be helped by whatever helps the Industry.

Western Electric Company

Wherever people look to electricity for the comforts and conveniences of life today, the Western Electric Company offers a service as broad as the functions of electricity itself.

Number 33 of a series

RELINING A TUNNEL

(*Continued from page 253*)

the track just outside the portal. This mixer delivered an average of ten yards per hour regardless of traffic. A six-inch steel pipe with one twenty-two-degree bend handled the discharge. The pipe had a maximum length of two thousand feet and terminated in a thirty-foot rubber hose. This flexible end enabled the contractors to deflect the pipe to any part of the cross-section circumference of the tunnel and deliver the concrete into the form beyond the bulkhead.

The rubber hose was connected to the horizontal steel pipe by a ninety-degree long radius steel bend and the forward end was brought back, making a compound curve through which the concrete was discharged into the space between the form and the old tunnel lining.

The provision of a baffle to intercept the concrete as it left the hose prevented any segregation of the aggregate and delivered the concrete in good condition at any part of the circumference of the tunnel, no spading or tamping being required. The rubber hose showed little deterioration for concrete delivered a short distance from the machine, but above five hundred feet the wear became more apparent and was considerable at the limit of the delivery which was made from the machine to the farther end of the tunnel in about one and one-half minutes. No wear was observed in the steel pipe.

The operation of the concrete plant required the services of five men, including a man at the bins, and exclusive of a variable number of men required to strip and clean the forms, extend the pipe and for other purposes.

When the forms had been completely filled up to a point about nine feet back of the transverse bulkhead, a twenty-four inch steel pipe nozzle was placed on the end of the rubber hose and concrete was forced in until all of the space was filled solid and word had been received that the last batch had been delivered from the mixer, when the nozzle was withdrawn and the remaining cavity was left open to provide an additional bond with the next section of concrete. The work was carried on with two ten-hour shifts per day and advanced at the rate of about one hundred twenty feet per week, using the four forms which remained in position until the concrete was at least forty-eight hours old. The removal of the forms always displayed a perfect, smooth surface with excellent finish which required no treatment whatever. Every time the forms were moved they were scraped, washed and oiled, thus providing a clean surface for the new concrete.

At the commencement of operations the concrete delivery pipe was laid the full length of the tunnel and at each form it was disconnected and the rubber hose connected to it, a section of lining concreted, the hose disconnected and moved back to the next form, reconnected and so on consecutively, until all of the forms had been concreted, when the operations were repeated.

The tunnel portals are exposed situations and at an elevation of one thousand two hundred feet above sea level, where the site was subject to severe cold and the tunnel was swept by a fierce draft, make uncomfortable working conditions in the winter. To eliminate this, the portals were both closed by heavy tarpaulin curtains that on the approach of a train were rolled up about five feet to clear the wing walls and then rolled transversely back to free the tunnel for the passage of a train, after which the portals were again closed, thus retaining the warm air and preventing the entrance of cold wind. The tunnel is ventilated by one intermediate shaft which, together with the plunger action of the trains assisted greatly by the escape of compressed air, maintained the atmosphere in such a condition that the men could work there with comfort. The storage bins were provided with steam coils to prevent the freezing of aggregate in extreme cold weather.

The main storage of aggregate was in a long pile alongside the main track on a spur elevated four feet above the surface of the ground, permitting the cars to dump automatically into storage. To deliver the aggregate from storage a second spur depressed about four feet below the surface was run alongside the pile so that the sand and gravel could be speedily shoveled into cars unloaded by clam shell bucket and derrick supplying the mixer bin.

At some places in the tunnel where it was desirable to reinforce the lining against possible heavy pressure, as, for instance, the foot of the intermediate shaft that will eventually be closed, sixty-pound rails were used to strengthen it and they were heated in groups of six or eight in open wood fires and then bent around a concrete form to a curve corresponding with the intrados of the lining.

HISTORY OF THE SOCIETY OF ARTS

(*Continued from page 255*)

Society of Arts" were printed and are on the shelves in the library. From 1891 to 1908 the "Proceedings" were published in the *Technology Quarterly*, a scientific journal in which the results of much of the research work carried on in the Institute laboratories was published. This journal was discontinued in 1908, and a "Bulletin of the Society of Arts" was issued during the two following years, 1908 to 1910, at the end of which time the Society took on a new field of activity. With the rise and growth during the 90's of the various scientific and engineering societies which became the logical place for the presentation of discoveries in pure and applied science, interest in the meetings of the Society of Arts waned. As time went on it became more and more difficult to attract audiences except to lectures of special interest such for example as Professor Cross' demonstration of X-rays a few weeks after their discovery by Röntgen, or by lecturers of national reputation. For this reason the number of public meetings gradually diminished until in 1910 there were held but six, and these further decreased to two in 1916. During this period, however, the Society undertook to publish and issue to its members a magazine called *Science Conspectus* in which the recent advances in science and engineering were presented in a popular manner. Mr. I. W. Litchfield, as secretary of the Society at that time, became its editor, and six volumes were published from 1910 to 1916. Many of the articles were contributed by members of the instructing staff, and the magazine was well received, but it could not hope to compete in circulation with such magazines as the *Popular Science Monthly*, and became a financial burden to the Institute. When, therefore, Mr. Litchfield resigned as editor in 1916, it was decided to discontinue the journal.

In order that the Society of Arts might still continue to serve the community, if not in its original purpose, at least in one more nearly meeting the needs of the present day, President Maclaurin sent out invitations in January, 1917, to the superintendents and principals of the high and preparatory schools in and about Boston to meet at the Institute to consider the advisability of the Institute offering a series of free popular science

(*Continued on page 290*)

The FULL Cone Spray thrown by SPRACO Center-Jet Nozzles assures greatest cooling efficiency because the maximum surface of water is brought in contact with the air. Over 1400 SPRACO Systems operating in 45 states and 23 foreign countries attest the universal acceptance accorded SPRACO Cooling Systems.

Spray Engineering Company

General Offices, BOSTON, MASS., U. S. A.

Manufacturers of
Air Washing Equipment
Spray Cooling Equipment
Paint Spraying Equipment
Flow Meters
Park Sprinklers

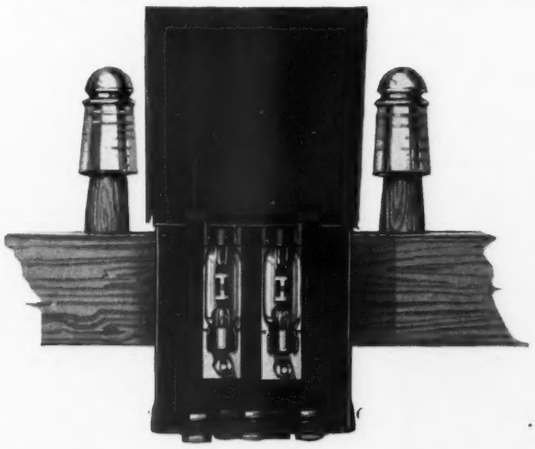
Engineers for
Spray Cooling Systems
Irrigation Systems
Aerating Reservoirs
Air Conditioning
Gas Washing

TRADE MARK

SPRACO
BOSTON

Lightning, the Bolshevik
IS AT ALL TIMES A MENACE

You never know in just what manner this enemy will strike.



VAC-M Arresters

Will render all low voltage signal circuits absolutely secure against the attacks of, not only lightning, but static, sneak-currents, high tension crosses, and all kindred disturbances.

National Electric Specialty Co.
(Sole Manufacturers)
Toledo, Ohio

Californian Hotel, Fresno, California
The R. F. Felchlin Co., Architects
Equipped with Haughton Alternating Current Elevators

A Revolutionary Development in Alternating Current Elevators

THE Haughton alternating current elevator for high speed use is developed on an entirely new and different principle. The elevators operate directly on alternating current. It is not necessary to transform alternating into direct.

Haughton Elevators are the only elevators in the world that do not use sealing magnets. This eliminates magnetic noise.

Quiet operation, safety, simplicity of mechanism and lessened upkeep have led to the selection of these elevators for many modern passenger installations.

THE HAUGHTON ELEVATOR & MACHINE COMPANY
TOLEDO, OHIO

New York
Pittsburgh
Cleveland
Detroit
Akron
St. Louis
Youngstown
Lima

HAUGHTON ELEVATORS

THE SOCIETY OF ARTS

(*Continued from page 288*)

lectures to school children of high school age. His idea was to arouse interest in science among the young people of the community by beautifully illustrated lectures similar to the popular "Christmas Lectures" given at the Royal Institution in London. His suggestion met with enthusiastic approval by those present. Four lectures were therefore arranged for on Friday afternoons at four o'clock during the winter of 1917. These lectures were chosen in the fields of physics and chemistry, and were most elaborately illustrated by experiments. The success of the undertaking was immediate, as the demand for seats far exceeded the capacity of the large lecture room seating 550. Pupils from the secondary schools would stand in line two hours before each lecture in order to insure getting desirable seats. Similar lectures in physics, chemistry, biology and aeronautics have been given annually up to the present time, with steadily maintained interest. So many pupils were unable to obtain tickets for the Friday afternoon lectures, it was decided in 1922 to repeat the lectures on Saturday afternoons at 2.30 o'clock. This made it possible for those in schools located at a considerable distance from Boston as, for example, Gloucester, Natick, etc., to attend the lectures. and audiences from three hundred to five hundred have been the rule on Saturday afternoons. It was also decided in 1922 to repeat the lectures in essentially the same manner on the following Sunday afternoons at four o'clock for the benefit of the general public. Attention was called to the lectures in the daily papers, and tickets were issued freely to all who requested them. This experiment has, in the two years it has been in operation, proved well worth while, as the Sunday afternoon lectures have attracted most appreciative audiences from three to four hundred persons.

It is the intention to continue this line of activity of the Society of Arts as long as the schools and the public maintain the active interest shown at present. Although quite different in purpose and character from the Society of Arts' lectures as originally conceived, it is felt that the present type of lectures may exert a wide influence in stimulating interest in pure and applied science, among those who may become future students at Technology, and in bringing into closer touch with the work of the Institute many in the community who would otherwise know it only from the outside.

POWER PLANTS OF CALIFORNIA

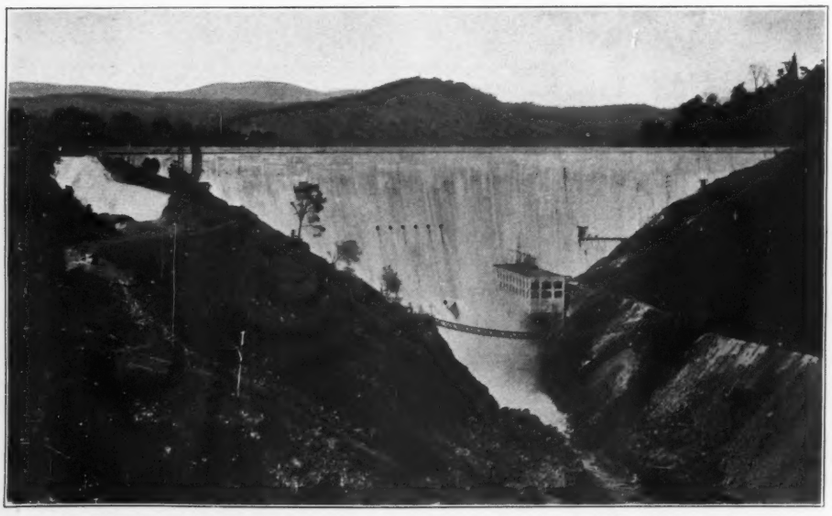
(*Continued from page 256*)

San Francisquito No. 1 and San Francisquito No. 2. These installations utilize the power of the Los Angeles aqueduct water supply. At the No. 1 plant there are three fourteen thousand horse power Pelton double overhung impulse turbines operating under an eight hundred seventy-foot head. The discharge from the No. 1 plant is carried by a six-mile tunnel which forms part of the aqueduct to a surge tank from which the water is led through two riveted steel penstocks seven feet in diameter and one thousand four hundred thirty feet long to power house No. 2, at the bottom of the canyon. The units in the latter plant are two twenty thousand five hundred-horse-power reaction turbines operating on a five hundred fifteen-foot head. The water after its discharge from the turbines again enters the aqueduct on its way to Los Angeles for consumption.

While in Los Angeles the steam plants of the Southern California Edison Company were inspected at Redondo and Long Beach. The capacity of the Redondo plant is fifty-three thousand six hundred horse power, while that of the Long Beach plant is sixty-three thousand horse power. The engines of the Redondo plant include three thirty-four and seventy inch by fifty-six inch combined, double, horizontal and vertical compound, side-crank engines of McIntosh Seymour make. Each unit has two horizontal high-pressure cylinders and two vertical low-pressure cylinders directly connected to an alternator. The plant was erected in 1908 and is used now as a standby station, only carrying about forty per cent of its capacity. The installation at the Long Beach plant are three vertical Curtis turbines of sixteen thousand one hundred, twenty thousand one hundred and twenty-six thousand eight hundred horse power capacity.

The plants visited of the Southern California Edison Company are as follows:

	Static Head	Number of Units	H.P. Capacity
Kern River No 1	862 feet	4	26,800
Kern River No. 3.	806 "	2	42,900
Kern River, Borel	206 "	5	13,400
Big Creek No. 1	1,900 "	3	64,300
Big Creek No. 2	1,860 "	3	64,300
Big Creek No. 8	700 "	1	30,200
Big Creek No. 3	Under Construction		90,000



DON PEDRO DAM OF THE TURLOCH AND MODESTO IRRIGATION DISTRICT

Much could be said about each plant as to its building, arrangement, type of machines, governors, pumps, air coolers, oil switches, bench control boards and its place in a large system. All have presented their individual problems and each is a study in itself. Comparisons afford the clearest understanding of volume. It is interesting to note, that, aside from the locks, the main features of constructing the Panama Canal was the excavating by steam shovels of thirty miles of open ditch. The Southern California Edison Company's "Big Creek Project" in its entirety necessitates the drilling of nearly eighty-four miles of tunnel, practically all of which is through solid granite, besides the erection of a chain of power houses, the total cost

(*Continued on page 292*)

The ABC of Good Paving

HERE'S a sound lesson in paving so brief and simple that you need not jot it down in your notebooks—you can "carry it in your head" until the time comes for you to apply it.

On your first paving project after college, remember "the ABC of Good Paving"—

Asphalt *for Filler*
Brick *for Surface*
Crushed rock, gravel, Crushed slag or Concrete *for Base*

and the "D" is Drainage, adequate and well-planned.

The result is an enduring, waterproof, frost-proof and traffic-proof roadway which is certain to give the longest service at least upkeep cost.

Remember—*"no brick pavement ever wore out from the top down."*

Send for free text-book, *"The Construction of Vitrified Brick Pavements,"* a handbook covering the subject in detail and containing recommended specifications.

NATIONAL PAVING BRICK MANUFACTURERS ASSOCIATION
ENGINEERS BUILDING CLEVELAND, OHIO

VITRIFIED Brick PAVEMENTS OUTLAST THE BONDS

POWER PLANTS OF CALIFORNIA

(*Continued from page 290*)

of which is estimated at three hundred twenty-five million dollars. Little is thought of these millions when an electric light is turned on and the millions more needed to keep ahead of the demand for electricity which has been increasing at the rate of eight per cent a year. Much time was spent inspecting all the above plants, a number of which were having additional units installed. In conjunction with the erection of the power houses there have been built dams, flumes and tunnels, the latter surpassing anything that has heretofore been attempted. The size of these tunnels, approximately sixteen feet by sixteen feet, are monstrous undertakings, necessitating steam shovels being used in excavating to expedite progress. This is truly a monument to engineering progress. In conjunction with the above plants there is being operated the longest high-voltage power transmission line in the world, bringing power from the Big Creek plants to Laguna Bell, near Los Angeles, a distance of two hundred twenty miles at a voltage of two hundred twenty thousand.

The plants of the San Joaquin Light and Power Corporation inspected were as follows:

	Static Head	Number of Units	H.P. Capacity
Crane Valley Power House...	116 feet	1	1,050
" " No. 3.....	406 "	3	5,900
" " No. 2.....	307 "	1	4,400
" " No. 1A.....	45 "	1	550
" " No. 1.....	1,412 "	4	24,000
Kerckhoff.....	350 "	3	54,300
Kern Canyon.....	215 "	2	12,000

The waters of the San Joaquin River are impounded by an earth-filled concrete core dam creating Crane Valley Reservoir of fifty thousand acre feet, which supplies water for the seven plants listed above. A progressive step in water power development has been the introduction of automatic and remotely controlled plants, these operating entirely without attendance. This is developing hitherto unprofitable blocks of power which accounts for the small plants in the Crane Valley system as noted above.

Going hand in hand with the development of the hydro-electric resources are the irrigation systems. The largest of these districts, namely the Turlock and Modesto Irrigation District, has just completed the Don Pedro Dam, the largest in the State. The dam is of the concrete arch type, two hundred eighty-three feet in height, a length along the crest of one thousand seven hundred feet, creates a water storage of two hundred eighty-nine thousand acre feet. The water so stored is for irrigation purposes, on which the development of the State's citrus fruit has been so much dependent. At the base of the dam is a power house of twenty thousand one hundred horse power capacity. The dam is honeycombed with tunnels for inspection purposes and chambers containing valves through which the control of water is regulated to the power house and the irrigation ditches below the dam.

Our next point of interest was a sojourn of several days in Yosemite Valley. Here we forgot about hydro-electric plants and turned our attention to the beauties of nature, that wondrously formed chasm which has awed all who view it. The everlasting hills, rich in great trees and filmy waterfalls, in birds and flowers, in trails that reward an easy mile a thousandfold or lead the more ambitious up into hidden ways and trackless canyons, is truly inspiring scenery. After leaving the Valley of Yosemite, owing to the roads not being in good condition, we had to travel two hundred miles to get into the Hetch Hetchy Valley, whereas if we had wings we would have flown only eighteen miles. Few realize that the Hetch Hetchy water supply and hydro-electric power project is of greater magnitude than any similar system in the United States. The system will supply four hundred million gallons of pure mountain water daily to four million people of the San Francisco Metropolitan District. In addition, this same water passing through huge water wheels installed in power plants will generate two hundred thousand horse power. The project takes its name from its principal reservoir site, Hetch Hetchy Valley, one hundred sixty-eight miles from San Francisco. O'Shaughnessy dam, named after the Chief Engineer of San Francisco, when completed, will contain three hundred seventy thousand cubic yards of concrete, will be three hundred forty-five feet high and impound sixty-seven billion gallons of water. To carry the tons of freight necessary for the dams, aqueducts and power plants remote from previously existing railroads, there has been built sixty-eight miles of standard gage road. When one of the engineers on the ground told us that the cost of driving parts of the tunnels was approximately one million dollars a mile we thought a decimal point had been misplaced but when we were conducted through a stretch of an eighteen-mile tunnel we saw much of the driving had been through solid granite, which accounted for the costly construction. In some places the tunnels are lined with concrete, the ingredients carried thousands of feet underground through tunnels and addits, mixed on the spot and placed behind the forms comprising the sides and top of the tunnel by a concrete gun.

Leaving Hetch Hetchy, our next interests were those plants of the Pacific Gas and Electric Company. Although there are many large plants of other power companies scattered between Hetch Hetchy, and Pit River No. 1, we made a jump of approximately two hundred miles due north without stopping to inspect the other plants. The completion of Pit River No. 1 is the initial plant of a chain which is to ultimately develop four hundred thirty thousand horse power. This plant is one of the finest and most distinctive hydro plants in the world. There are installed two forty-six thousand six hundred horse power Allis Chalmers vertical turbines operating on a four hundred twenty-foot head, the largest hydro-electric units in service in the United States. From this station a two hundred twenty thousand volt line transmits the power over a two-hundred-mile span to San Francisco. This transmission line in itself is of interest. Part is over wooded mountains, foothill country and finally prior to entering the outskirts of San Francisco crosses Carquinez Straits with a six thousand four hundred foot span between towers. Pit River No. 1 is a handsome, reinforced concrete building of striking Gothic design, a monument in itself.

Mere figures mean little to the average student. An adequate appraisal of what hydro-electric development means can be obtained from the following: Every time one horse power in power plant development in the mountains is connected to any of the giant transmission lines it means that twelve acres of unproductive land worth three hundred dollars an acre will have applied to it four horse power in motors for irrigation and general use, producing one thousand dollars in new crops per year, thereby increasing the original value of the land to two thousand four hundred dollars an acre. Likewise, to industry, it means an equally wonderful thing, for every time twenty-five horse power is harnessed in the mountains, an average of a factory and a half starts up setting in motion many motors, turning the wheels of industry and providing employment for thirty-three more people and producing over two hundred thousand dollars per year in new commodities. There is no greater builder of agriculture and industry than these great power plants which we saw.

Just off the press!

Contains valuable information on explosives for

Construction Work

THIS new ATLAS book, consisting of one hundred and twenty fully illustrated, attractively printed pages, contains information that will prove of utmost value to users of explosives.

It tells the how, when, where, what and why of explosives. It describes the many kinds and grades of explosives and blasting supplies in a way that will appeal to every user of explosives.

We now are distributing this valuable book of blasting information, without charge, to those who request it. Write today to the nearest office for your copy.

ATLAS
AMMITE
— cannot freeze —

ATLAS POWDER COMPANY
WILMINGTON, DELAWARE

Branch Offices:
Allentown, Pa.; Birmingham, Ala.; Boston, Mass.; Charleston, W. Va.; Chicago, Ill.; Des Moines, Iowa; Houghton, Mich.; Joplin, Mo.; Kansas City, Mo.; Knoxville, Tenn.;

ATLAS EXPLOSIVES

Branch Offices:
McAlester, Okla.; New Orleans, La.; New York City, N. Y.; Norristown, Pa.; Philadelphia, Pa.; Pittsburg, Kans.; Pittsburgh, Pa.; Pottsville, Pa.; St. Louis, Mo.; Wilkes-Barre, Pa.

An Engineer's Duty

No structure is properly designed or built unless it functions safely. There is no more important feature. Therefore it is the engineer's first duty.

Build Safe Walkways

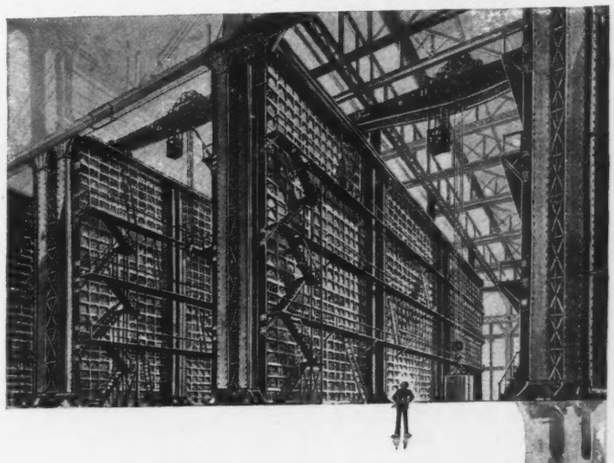
No hazard is so common, causing such large numbers of accidents and heavy compensation claims as "Falls." The Aetna Life Insurance Company paid for injuries to its insured $594,499.31 for 6,395 claims for "Falls on Stairs or Steps"; and $2,718,337.04 for 33,360 "Falls" of all kinds.

USE

FERALUN
Anti-Slip Treads

Send for Sample and Literature

American Abrasive Metals Co.
50 Church Street, New York
Representatives in all principal cities



"Making a Study" of Something

A man "goes to school" merely to catch up with the parade, as it were, to get the universally available facts about his chosen science or profession.

If he would go still further he must continue to study. The sum of all human knowledge today represents the things revealed to men who "made a study of it" right on through college days and the business or professional career that came later. The college men in the Bunting Brass and Bronze Company are still students.

THE BUNTING BRASS & BRONZE COMPANY
TOLEDO, OHIO
Branches and Warehouses at

New York
245 West 54th Street
Circle 0844

Chicago
722 South Michigan Avenue
Wabash 9153

Cleveland
710 St. Clair Avenue, N. E.
Main 5991

San Francisco
198 Second Street,
Douglas 6245

Boston
36 Oliver Street
Main 8488

BUNTING BUSHING BEARINGS

MERCERIZATION

(*Continued from page 257*)

The wash water should be in plentiful supply, otherwise the caustic might not be sufficiently washed out of the yarn. In such cases the caustic is carried over to the acid boxes, the acid having no effect on the yarn. Again care should be taken not to carry any of the acid over into the final washes. The acid should not be held at too great a strength. Where this occurs the last vestige of acid often has not been removed by the washing. This not only contributes to uneven dyeing and causes tender yarn but it is a source of trouble to the knitter generally.

After a proper washing, if the yarn is to go to the kiers for bleaching, it may miss the drying machine and be carried down to the trucks, directly from the mercerizing range. In this case, a small amount of caustic left in the yarn will be an asset in boiling.

From this point on, the yarn is bleached in the regular way and sometimes super-bleached. Great care should be taken in drying the yarn to see that this is thoroughly done to avoid mildew and save trouble in splitting the warp.

The range for mercerizing cotton goods in the piece is similar to the stenter or tenter, as it is now more generally called and used in printing, dyeing and bleaching operations. These tenters are made in any width and length, depending wholly upon the work to be done. Usually a mercerizing tenter is about fifty feet long. There are two endless chains, one on each side of the tenter. These operate on sprockets at each end and carry clamps which run in slotted grooves the length of the machine. The fabric coming from the mangle where it has been saturated with caustic soda passes on to this tenter where it is gripped by the clamps. This tenter chain carries the fabric on to where a tension is caused by the two sides of the tenter separating a few inches more than at the entering end. The stretched fabric is then sprayed from over top; the tension slackens and mercerization has been completed. The fabric continues the length of the tenter where the clips open and release it. Following this the fabric goes through a bath of weak sulphuric acid and from there to the wash.

NON-FERROUS ALLOYS

(*Continued from page 258*)

This tedious rule-of-thumb procedure is expensive and unscientific, and often yields patterns that are almost sure to produce defective castings. Of course in the production of a large number of castings from the same pattern, the expense involved in making the pattern by the above method will be absorbed and distributed over the output, so that it may appear insignificant when referred to the selling price per pound of castings; but the principle is incorrect and is productive of many wasters.

Of course, any casting should be designed with especial regard to foundry practice — that is, as to the alloy to be used, the gating necessary, size of sections, pouring temperature, and other factors. The proposed design, which should be the result of the combined knowledge of the foundrymen, pattern maker, metallurgist, and designing engineer, should be submitted to the pattern maker with a statement of the definite conditions of the foundry practice to be followed. If, in addition, accurate data were available covering the contraction of the alloys, together with information as to the effect of the above-mentioned factors upon the contraction, it would then be a simple, technical matter to make a pattern which would yield castings of the required dimensions with a minimum number of wasters in production. Little of this information is available, and what is on record seems to be more or less ignored in practice.

The most important factors affecting the contraction of an alloy on casting

(*Continued to page 296*)

Technology Branch, H. C. S.

THE newest books on technical and scientific subjects, published by John Wiley & Sons, and McGraw-Hill Book Company, are sent to us as soon as they are off the press. We should be glad to have you come in and look them over.

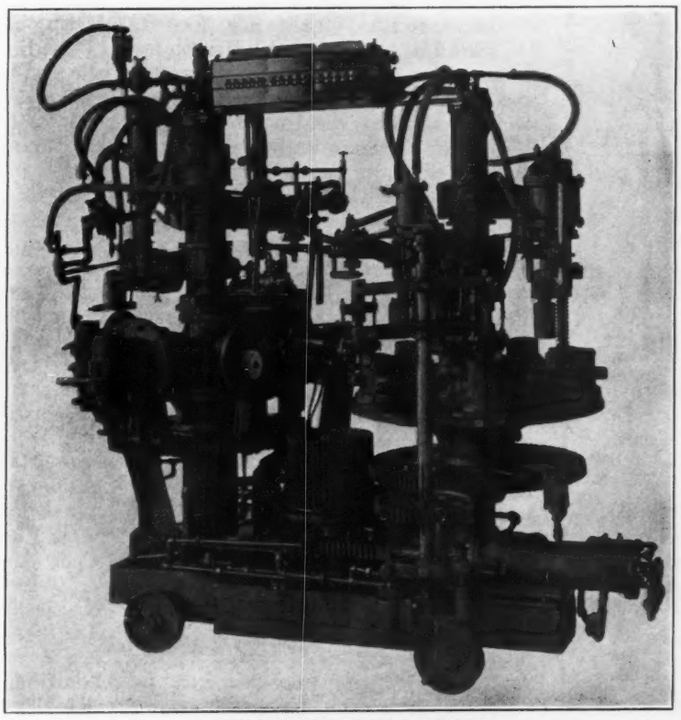
Our stock of Drawing Instruments is selected from the most famous manufacturers — Alteneder, Keuffel & Esser and Schoenner. These range in price from $36.75 to $5.00.

The Keuffel & Esser slide rules are standard. Those most commonly used at M. I. T. are the Polyphase, Polyphase Duplex, and the Log Log Slide Rule. We can supply these rules from stock. Prices quoted on request.

We are the natural source of supply for Drawing Boards, T Squares, Triangles, Drawing Ink, Tracing Cloth and Paper. We specialize on merchandise used in technical training.

At your service.

TECHNOLOGY BRANCH, H. C. S.
76 MASSACHUSETTS AVENUE
CAMBRIDGE, MASS.



A MODERN BOTTLE MOLDER

Pre-eminence

PRE-EMINENCE—that goal that all manufacturing interests aim for; yet so few attain. It is the result of long and perfect service, coupled with the most efficient workmanship obtainable, all guided by a thorough, practical, far-sighted management. To this class a select number belong, each member foremost in his line of endeavor.

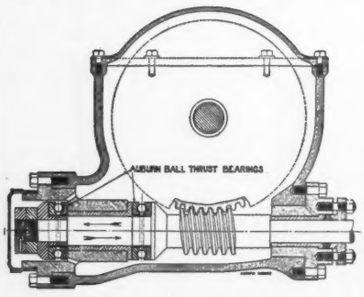
For generations THE SALEM GLASS WORKS has been capably serving its customers, ever caring for their best interests, and exercising the utmost diligence in developing its facilities for proper manufacture of the world's most sanitary container, the Glass Bottle. They have added a very appreciable amount to the development of bottle manufacture. Their efforts have, to a very considerable degree, made it possible to obtain quality and quantity production of bottles, made in a multitude of colors, finishes, and shapes. To them is accorded by everyone of worth, a position in the really pre-eminent manufacturing class.

To their old customers they offer the same reliable service, coupled with an exact knowledge of the necessary requirements to meet the demand. To new customers they offer a fertile field for obtaining thorough workmanship. Their staff of expert engineers and competent managers is ready at all times to give their prompt attention to your container problems.

SALEM GLASS WORKS

SALEM, NEW JERSEY

PRODUCERS OF THE BETTER BOTTLES



Worm Drives operate more smoothly when equipped with

AUBURN BALL THRUST BEARINGS

Write for loose-leaf Data Sheets

Trade Mark

AUBURN BALL BEARING CO.

44 Elizabeth Street **ROCHESTER, N. Y.**

NON-FERROUS ALLOYS

(*Continued from page 294*)

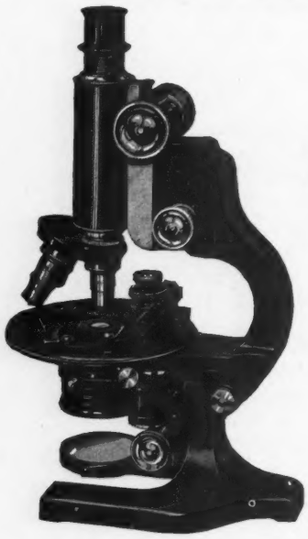
include (1) chemical composition of the alloy, (2) pouring temperature, (3) cross section of the bar poured, (4) length of the bar in relation to its cross section, (5) character of the mold, and the method of molding, (6) gas occlusion, and overheating of the melt.

The contraction of a given alloy may be markedly altered by changing the composition within relatively small limits, and no general figure is sufficiently accurate to indicate the contraction of a class of alloys. Of course, in considering the linear contraction of any alloy and its piping and contraction in volume on freezing, it is necessary to consider the diagram of thermal equilibrium, and examine the phase changes that take place at the particular composition during freezing and subsequent cooling. The course of freezing of solid-solution and eutectiferous alloys can be examined with profit in the study of contraction by reference to the diagram of thermal equilibrium. The phase relations and changes existent in the freezing range and below have a bearing on the linear contraction of the alloy and on its soundness. There may possibly be phases of expansion during the course of freezing and also on cooling in the solid state. These will affect the pattern allowance to be made in actual casting practice.

The linear contraction of a metal or alloy on pouring into a mold is a function of the pouring temperature since less metal can be put into a mold cavity of a given size at a higher temperature than at a lower one. Theoretically, the higher the pouring temperature, the greater the contraction, owing to the decrease in density of the alloys in the liquid state with increasing temperatures; but actually an intermediate pouring temperature normally yields a greater contraction than a high or low pouring temperature. The fact that less contraction is given by pouring at a higher temperature than at an intermediate one is traceable to the dissolution of gas in the alloy. As is well known, metals and alloys dissolve more gas with increasing temperatures, and when this gas is given off on freezing, it causes expansion, and therefore interferes with the normal contraction. The pouring temperature affects also the presence of blow-holes and in addition, influences the rate of cooling. A high pouring temperature will cause

(*Continued on page 298*)

MICROSCOPES, MICROTOMES AND ACCESSORIES



Types from most elementary to those required to meet the most exacting demands.

Send for Special Bulletin

L. E. Knott Apparatus Company

Scientific Instrument Makers

CAMBRIDGE, MASS.

28-12-P-T.E.N.

Founded 1878 — OKONITE — Incorporated 1884

TRADE MARK

The Standard for Rubber Insulation

OKONITE PRODUCTS

are available for all electrical purposes.

They have stood the test of time and are recommended by prominent Electrical Engineers everywhere.

- Power Cables (Okonite and Varnished Cambric)
- Submarine Cables
- Parkway Wires & Cables
- Signal Wires
- Car Wires
- Jumper Cables
- Plough Leads
- Locomotive Headlight Wire
- Telephone and Telegraph Potheads
- Telephone & Telegraph Wires
- Okocord (hard service cords)
- Portable Cords
- Ignition Wires
- Okonite Splicing Materials
- Okoloom (Hard Finish for Hard Service)

Write for handbook "INSULATED WIRE & CABLE"

THE OKONITE CO., Passaic, N. J.

Sales Offices
NEW YORK ATLANTA SAN FRANCISCO

Agents
Central Electric Co., Chicago, Ill. The F. D. Lawrence Electric Co., Cincinnati, Ohio
Pettingell-Andrews Co., Boston, Mass. Novelty Electric Co., Philadelphia, Pa.

EFFICIENCY

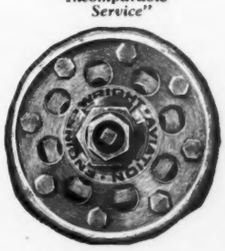
THE remarkably low fuel and oil consumption, together with the extremely light weight per horsepower make the Wright "T" engine the most efficient thus far produced.

The small space occupied by the "T" engine in planes adds tremendously to the general efficiency of the entire unit. The frontal area per H.P. is lower than others. The compactness is such they frequently can be installed in the same space formerly occupied by a 400 H.P. engine.

Wright production skill, together with Wright designing and engineering experience are constantly creating higher standards in aeronautical efficiency.

WRIGHT AERONAUTICAL CORPORATION
Paterson, New Jersey, U. S. A.

"The Identification of Incomparable Service"



Efficiency tests disclosed that fuel and oil consumption of the Wright "T" engine in flight corresponded very closely in gallons to the consumption of a smaller engine in the same plane. The efficiency of the "T" throttled down to flying conditions compared most favorably with the comsumption tests of smaller engines.

RATINGS

T-2	T-3
525 H.P. heavy duty	*575 H.P. heavy duty*
600 H. P. high speed	*650 H. P. high speed*
Weight 1150 lbs.	*Weight 1100 lbs.*

WRIGHT MODELS T ENGINES

CONTRACTION AND SHRINKAGE OF NON-FERROUS ALLOYS

(*Continued from page 296*)

a slower rate of cooling than a low one, and a rapid rate of freezing yields greater contraction than a slower rate, apparently, at least, in alloys where there is a time-interval of freezing. This is also in accordance with the fact that a high pouring temperature yields a greater contraction than a low pouring temperature.

In casting practice, it is well known that the contraction depends upon the cross section of the casting; various workers have shown that the total linear contraction is a function of the cross-sectional area of the bar poured. Given all other conditions the same, the smaller the cross-sectional area of the bar the less the contraction. In a casting, the contraction allowance is dependent upon the mass of the casting, its design, and the relation between the thick and thin sections. According to Turner, when an alloy is cast in the form of a cube, the alloy contracts uniformly in all directions, but in a bar the contraction takes place chiefly in the direction of the length, and the thinner the bar the greater is the disproportion between the contraction in the different directions. He states that this holds for cast-iron, while copper and certain of its alloys behave in an exactly opposite manner. From experiments made with aluminum alloys, it was shown that with greater length for a given cross section the contraction is less.

Other conditions being the same, the linear contraction of alloys when poured into chill molds is greater than when poured into sand molds, and this must be connected necessarily with the rate of freezing. A mold of high thermal conductivity will dissipate heat more rapidly than one of lower thermal conductivity; and the rate of freezing will be faster in the first type of mold. Therefore, the contraction allowances in die casting are necessarily different than in sand casting. It has been shown by Turner that where there is a freezing interval — that is, where there is a temperature range between the liquidus and the solidus — sand-cast bars have lower density than chill-cast bars. Thus, slower cooling gives less density than rapid cooling, which would indicate greater contraction for chill-cast bars than sand-cast ones. This does not accord with experimental results obtained for aluminum alloys, but does hold for brasses under definite conditions.

In sand-casting practice, the contraction allowance to be made is influenced necessarily by the method of molding — that is, as to number, size and position of gates and risers. The normal free contraction of an alloy may be hindered by too many risers, which cause hanging of the casting in the mold and cause shrinkage cracks in some cases. Too hard ramming may interfere also with the contraction. The function of a riser is to feed liquid metal to a contracting portion of a casting, thereby preventing porosity and draws, so that the normal shrinkage of a casting is affected by the size and number of risers attached. When a casting is thoroughly fed with risers, the effect of the liquid shrinkage is minimized in certain portions of the casting; but in other portions the full contraction in volume obtains on pouring the casting.

Desch and others find that an overheated melt contains more gas to the moment of pouring than one that has been heated merely to the correct pouring temperature, and apparently overheated melts readily remain supersaturated with gas. As is well known, metals and alloys do not obey Henry's law, but the higher a metal is heated in the liquid state the more gas it dissolves. The effect of gas occlusions, resulting from high melting and pouring temperatures, upon the contraction of alloys is to lessen the normal contraction owing to the evolution of gas on freezing, which causes actual expansion, and therefore interferes with the normal free contraction. While pouring at a low temperature after cooling from a high melting temperature minimizes the deleterious effects of overheating, an overheated melt will give rise to blowholes and porosity owing to the evolution of gas on freezing.

W. A. WOOD COMPANY

Established 1868

373 ATLANTIC AVENUE, BOSTON, MASS.

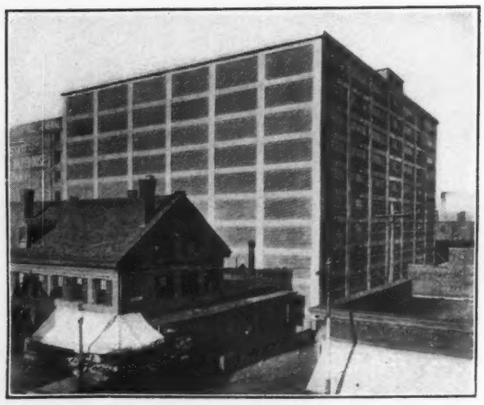
"The Right Oil for the Right Place"

With more than a half century of practical experience in adjusting oils to the special conditions under which they are to be used in individual plants.

W. A. WOOD COMPANY

373 ATLANTIC AVENUE BOSTON, MASS.

Lubricating Oils and Greases for all purposes Perfection Motor Oils



WILLIAM T. REED CO.

Building Construction

200 DEVONSHIRE STREET, BOSTON

We are organized and equipped for the efficient handling of mercantile and industrial building construction of all descriptions

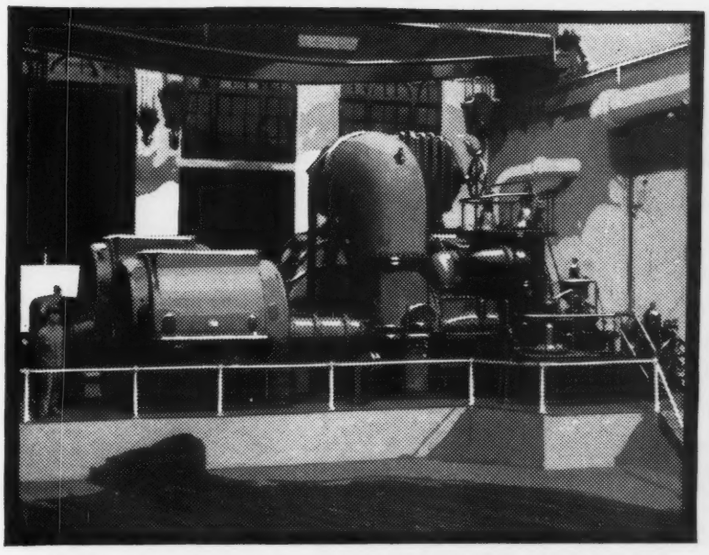
Formerly New England Concrete Construction Company

A Record Still Unbroken

At 5:20 P. M., March 8th, 1920, Westinghouse Turbine Established World's Record for Continuous Running.

What Engineering Owes to Good Workmanship

WHEN Westinghouse installed a 45,000 K. W. Turbine in the power house of the Narragansett Electric Light Company, Providence, R. I., early in December, 1919, there was no thought of more than the average weekly power house run. Abnormal weather conditions, however, brought so steady a demand for power, that the unit was not shut down until March 8th, 1920, after a continuous run of 84 days, 11 hours, and 36 minutes.



45,000 K. W. Westinghouse Cross-Compound Turbine Unit at the Station of the Narragansett Electric Light Company, Providence, R. I.

This was especially remarkable in that the unit consists of two turbine generator sets, each of which operates independently of the other, so that the result was the mechanical equivalent of operating a single machine continuously for 169 days.

If space permitted, many astounding figures could be cited—about the K. W. H. generated during this period, the water and coal used, the cooling system, the oiling system, etc.

For example, to keep the generators cool, over 18,000,000,000 cubic feet of air passed through them, which equals 2,000 times the total weight of the generators and their bed plates.

Equally impressive, oil was pumped through the self-contained lubricating system to the bearings at the rate of 600 gallons a minute. Had the oiling system failed for only 30 seconds, the bearings would have been wrecked, and other parts of the unit harmed!

There is interesting history back of the operation of Westinghouse Turbine Units of 3,000 K. W. and higher. Notable records have been made in many of the world's great power plants, performance that is a tribute to remarkable engineering and good workmanship.

Westinghouse

ACHIEVEMENT & OPPORTUNITY

WESTINGHOUSE ELECTRIC

PUTTING RADIO TO WORK

(*Continued from page 259*)

Another interesting development was the use of this principle to ring a regular polarized telephone bell. This was demonstrated at the spring inspection by the War Department of the Signal Unit at Ohio State University. The principles involved are as follows: At the transmitting end a tuning fork is caused to vibrate at sixteen cycles per second. This is the frequency used by the Telephone Company on their alternating current for ringing bells. This frequency modulated a carrier wave. At the receiving end pulsations of sixteen cycles per second are received in the manner described above. The current from the Western Electric Amplifier goes to a specially constructed microphonic relay. A platinum contact is suspended at the end of a thin steel wire, of about one and one-half inches in length. It rests lightly on a platinum disk contact in the center of the relay diaphragm (see photo B). The relay is the ordinary telephone receiver, in the picture, without a cap, which you see near the transformer and bell. The pulsations acting on the diaphragm cause a slight movement to take place. This tends to disturb the platinum contacts and a slight sparking ensues. Now the contacts are in series with eight-volt battery and the primary of a transformer. The back E.M.F. from the transformer, due to this slight sparking, generates a local oscillatory discharge. This is picked up by the local antennae, and regenerates back into the radio set, causing the diaphragm to vibrate radically and completely breaking the circuit. There are two actions taking place here, but the enormous speed of radio activity makes them almost simultaneous, and practically so, for the slow frequency of sixteen cycles per second. The contacts, therefore, are making and breaking at the regular bell frequency. The secondary of the transformer goes to the polarized bell. The transformer ratio is about one to four, so that the bell is receiving about thirty-four volts A.C., at the desired frequency. The bell rings loud and clear, in fact as efficiently as on your own telephone.

In concluding there is one thing to which the writer will call special attention. It was found that upon examining the tuning forks at the receiving station, on the radio control device, that the energy manifested by the vibration of this receiving fork was as great, if not greater, than the energy of the actuating fork at the transmitting station. This is an interesting thought in connection with power transmission by radio.

Vibration is the key to the great secrets of nature. Pythagoras, more than twenty-four centuries ago, taught that everything in nature has a number. The Victorian critics refer to this as an interesting conceit of the Pythagorean philosophy. If you will read Millikan's article, however, in the October 1923 number of *Scribner's Magazine*, you will note that he shows where the frequencies of the ninety-two elements have been definitely determined and that they bear a progressive arithmetic relation to one another. Each element has its number. If we could change the frequency of the atom of mercury we could produce gold.

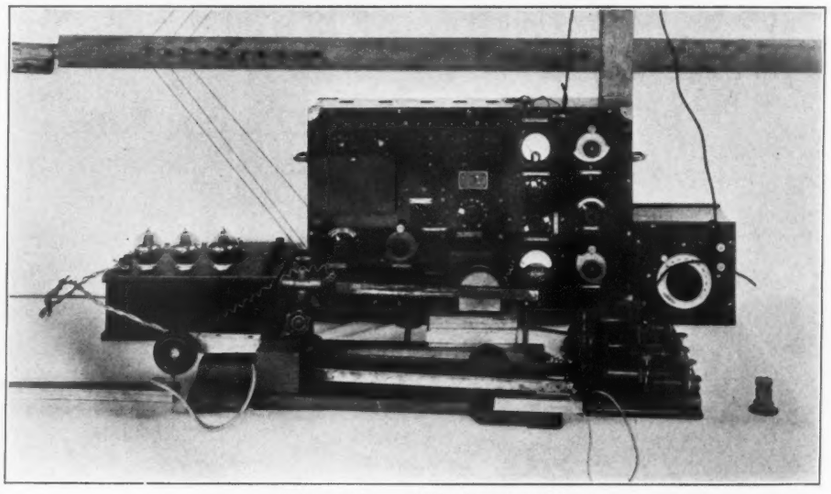


FIGURE B. THE RECEIVER

Selected Grades

Anthracite

and

Bituminous

COAL

BURTON-FURBER
COAL COMPANY
50 CONGRESS STREET
BOSTON

EVERY engineer should know APOLLO Best Bloom and Apollo-Keystone Galvanized Sheets, American Bessemer and Open Hearth Steel Sheets; and KEYSTONE Copper Steel

Rust-resisting Black and Galvanized

SHEETS

We manufacture SHEET AND TIN MILL PRODUCTS for all purposes—Black Sheets, Galvanized Sheets, Corrugated Sheets, Formed Roofing and Siding Products, Galvanized Tank, Culvert and Flume Stock, Special Sheets for stamping, Stove and Range Sheets, Automobile Sheets, Electrical Sheets, Roofing Tin Plates, Bright Tin Plates, Black Plate, Etc. Sold by leading metal merchants. KEYSTONE quality is of particular interest to you. Send for booklet.

AMERICAN SHEET AND TIN PLATE COMPANY, Frick Bldg., Pittsburgh, Pa.

AMERICAN SHEET AND TIN PLATE CO. APOLLO BEST BLOOM PITTSBURGH KEYSTONE COPPER STEEL

After you've done your best—
What then?

THE day is not far off when you may be in charge of plant production. Your first duty will be to take the equipment you have and bring production up to the highest possible level.

Let's suppose you've done that. Machines are in good order. Work is properly scheduled. Time studies have been carefully made. Yet costs are still too high.

Then the only solution will be to get new machines which can do the work faster at lower power and labor costs.

Such machines as the Brown & Sharpe No. 21 Automatic Milling Machine have done wonders in speeding up production and lowering costs.

Get acquainted with this machine now. Write for this fully illustrated book describing the machine and several typical jobs on which it has cut costs. Send for your copy today.

BROWN & SHARPE MFG. CO.
Providence, R. I., U.S.A.

BROWN & SHARPE
Machines - Tools - Cutters
WORLD'S STANDARD
FOR QUALITY

DAYLIGHT ILLUMINATION.

The angle of refraction being equal to the angle of incident, it is a simple matter to determine the correct angles to use in manufacturing glass which will give good illumination. But for proper industrial plant illumination, there is more to be considered than mere deflection of light. The direct beam of light must be eliminated in order to prevent sun glare, which is objectionable on account of its causing heavy shadows and strong contrasts which decrease the efficiency of employees and necessitate the use of shades which in turn reduce the light to such an extent that daylight illumination any distance from the light source is not sufficient. Therefore, in order to produce a glass which when used in the windows of industrial plants will produce as near to ideal illumination as possible, we must first eliminate the direct rays of the sun by deflecting the light to the ceiling and side walls which re-deflect it back to a distance 25 to 50 feet from the window throughout the entire working area. To accomplish this we have scientifically designed a type of glass which is named "Factrolite."

Factrolite consists of 30 ribs to the inch, running at right angles, forming 900 pyramidical prisms or 3,600 light deflecting surfaces which completely disintegrate the direct beam of light from the sun. Furthermore, the depressions in the surface of Factrolite are so slight that the accumulation of dirt and dust is minimized and can be perfectly cleaned with an ordinary dry scrubbing brush. Incidentally, the cleaning of windows is most important for keeping up production and increasing the efficiency of any industrial plant and should be given more consideration in plant management.

If you are interested in the distribution of light through Factrolite, we will send you a copy of Laboratory Report—"Factrolited."

MISSISSIPPI WIRE GLASS CO.,
220 Fifth Avenue,
St. Louis. New York. Chicago.

JAMES P. BARNES

(*Continued from page 260*)

provide a new and attractive means of transportation, appealing to street car riders and automobile owners alike.

"He took another hitch in his belt and went to it." Following an intensive study of the situation he brought about the organization of the Kentucky Carriers, Incorporated, an automobile coach company operating on the streets of Louisville. The stock of the Company is owned by the Louisville Railway Company, with Mr. Barnes as its President. The Company started its operation with six single-deck coaches, later added six more single-deck coaches, and by the middle of September plan to place in operation twelve double-deck automobile coaches, furnishing a service at 10-cent fare that is calculated to induce the average automobile driver to leave his automobile at home and patronize the automobile coach. The coach service is meeting with substantial approval and has opened a new epoch of transportation in the South.

Somewhere back in my youthful days I remember hearing "All work and no play makes Jack a dull boy." A normal man should have enough of both. The writer has always maintained that any man who is particularly well informed on only one subject, and uninformed on others, is a fit subject for the insane asylum. In the words of the street "He's a nut," for his mind is abnormally developed. It was hard work that brought Mr. Barnes from Boston Tech to the presidency of one of our largest transportation systems, but hard as he worked, when he played he played equally hard, in order to maintain a well-balanced life.

Every man must have his avocation as well as his vocation. With Mr. Barnes it was music. Not only did he devote six years to the study of the violin, but he has done quite a bit of solo work and, besides being a member of a string quartette, was leader of the Glee Club while at Tech, and before this was with the Syracuse Glee Club for two years as violin soloist. There is no reason at all why a man should not combine music, and a love of things musical, with street railroading and the harmonious relations between the traveling public and the corporation.

Mr. Barnes' work in connection with club and civic affairs has also been very pronounced. He was President of the New York Electric Railway Association in 1917 and is now President of the Central Electric Railway Association, as well as being a member of the Executive Committee of the American Electric Railway Association. He is President of Louisville Council, Boy Scouts of America, and Treasurer of The Arts Club. He is a director of the Citizens Union National Bank, the Inland Waterways Company and the Louisville Industrial Foundation. He is a member of the Pendennis Club, the Louisville Country Club, the Audubon Country Club, the Sleepy Hollow Club, the Rotary Club, the Advertising Club and the Louisville Board of Trade.

He is a member of the Technology Club of New York, the Transportation Club and the Engineers Club of New York City, as well as the Old Colony Club. He is a Knights Templar, a thirty-second degree Scottish Rite Mason, member of the Shrine, and is Grand Prior of the Consistory of Kentucky.

He is now building in Louisville, overlooking Cherokee Park, which is one of the finest natural park formations in the country, a very beautiful home, the just reward for a life of hard work and a life spent in doing what he could to make the other fellows' means of transportation to and fro as comfortable as possible.

When he walked forth from Boston with his diploma under his arm, he did not walk forth with the idea that the world owed him a living and that diploma was his collection warrant, but he walked forth into one of the hardest fields of endeavor and has made good — and always —

"He Takes Another Hitch in His Belt and Goes to It!

STARKWEATHER & BROADHURST, Inc.

Engineers and Contractors
for
Power Plant Apparatus

TELEPHONE CONGRESS 1810 **79 MILK STREET, BOSTON**

Established 1870 **Incorporated 1890**

THE WARREN SOAP MANUFACTURING COMPANY

Textile Soaps

77 SUMMER STREET **BOSTON, MASSACHUSETTS**

SAMSON SPOT SASH CORD

Trade Mark Registered U. S. Patent Office

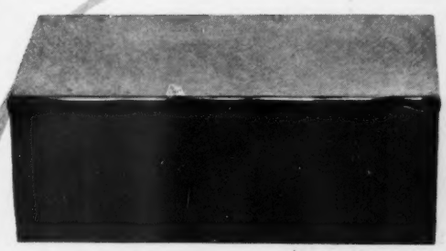
Made of extra quality cotton yarn, carefully inspected and guaranteed free from all imperfections of braid or finish. The colored spots are our trade-mark, used only with this quality.
We make braided cord of all sizes, kinds and colors, for all purposes, including sash cord, clothes lines, trolley cord, signal cord, arc lamp cord, and many special cords for special purposes.

CATALOGUE AND SAMPLES GLADLY SENT ON REQUEST

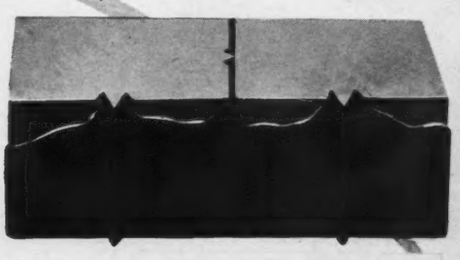
SAMSON CORDAGE WORKS **88 Broad Street, Boston 9, Mass.**

KREOLITE KOUNTERSUNK - LUG - BLOCKS

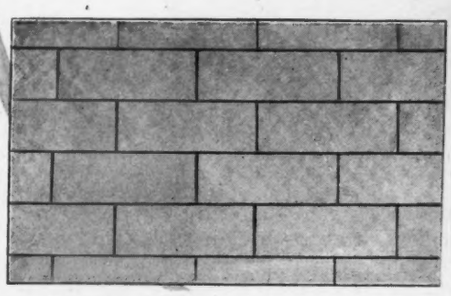
"The Paving that's Saving"



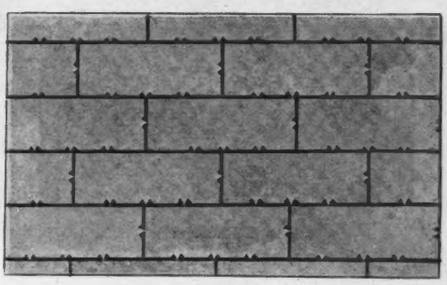
1—Showing imperfect penetration of filler with common rectangular block.



3—Showing nearly perfect penetration of filler with Kreolite Kountersunk Lug Blocks.



2—Plan view of plain or common rectangular blocks.



4—Plan view of Kreolite Kountersunk Lug Blocks.

KREOLITE Kountersunk Lug Wood Blocks are designed for bridge and street paving, and, with a slight variation of the kountersunk feature, for interior factory flooring.

This method of construction permits the penetration of the bituminous filler the entire depth of the block on all sides (see figure 3) securely binding it to the base and making a firm waterproof joint. The filler (our special make) is applied hot in liquid form and hardens when cool. The block cannot become loose because it is firmly attached to the base and to the adjacent blocks on four sides. In laying, only the tough end grain is exposed to wear.

In figure 2, the blocks make a good appearance, but is another case where beauty is only skin deep. The filler solidifies and fills only the upper part of the joint (see figure 1). Note bonding power, so essential to the permanence of any block pavement, as shown in figure 4.

To all City and County Officials, Contractors, Architects, Manufacturers, and others interested, we extend, gratis, the services of our trained engineers.

Write for detailed specifications and information

The Jennison-Wright Company, 79 Kreolite Bldg., Toledo, Ohio

THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

CAMBRIDGE, MASS.

THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY offers courses each of four years' duration, in Civil, Mechanical and Electrical Engineering; Naval Architecture and Marine Engineering; Mining Engineering and Metallurgy, and Geology and Geological Engineering; Architecture and Architectural Engineering; Chemistry, Chemical Engineering and Electrochemical Engineering; Biology and Public Health, and Sanitary Engineering; Physics, General Science and General Engineering; and in Engineering Administration. These courses lead to the Degree of Bachelor of Science.

To be admitted to the first year class, applicants must have attained the age of seventeen years, and must satisfactorily fulfill entrance requirements in Algebra, Plane and Solid Geometry, Trigonometry, Physics, Chemistry, English, History, and French or German and one elective subject. Examinations are required in all subjects except Chemistry, History and the elective, the requirements for which are fulfilled by the presentation of satisfactory certificates. A division of these entrance subjects between different examination periods is permitted.

Entrance examinations are held at the Institute in September. In June, applicants will be examined by the College Entrance Examination Board in Boston, New York, Philadelphia, Chicago, and many other cities in America and Europe. A circular stating times and places is issued in advance by the College Board.

Graduates of colleges and scientific schools of collegiate grade, and in general all applicants presenting satisfactory certificates showing work done at another college corresponding to at least one year's work at the Institute, are admitted, without examination, to such advanced standing as is warranted by their previous training.

Graduate courses leading to the degrees of Master of Science, Master in Architecture, Doctor of Philosophy and Doctor of Science are also offered. Special Research Laboratories of Physical Chemistry, Applied Chemistry and Science have been established.

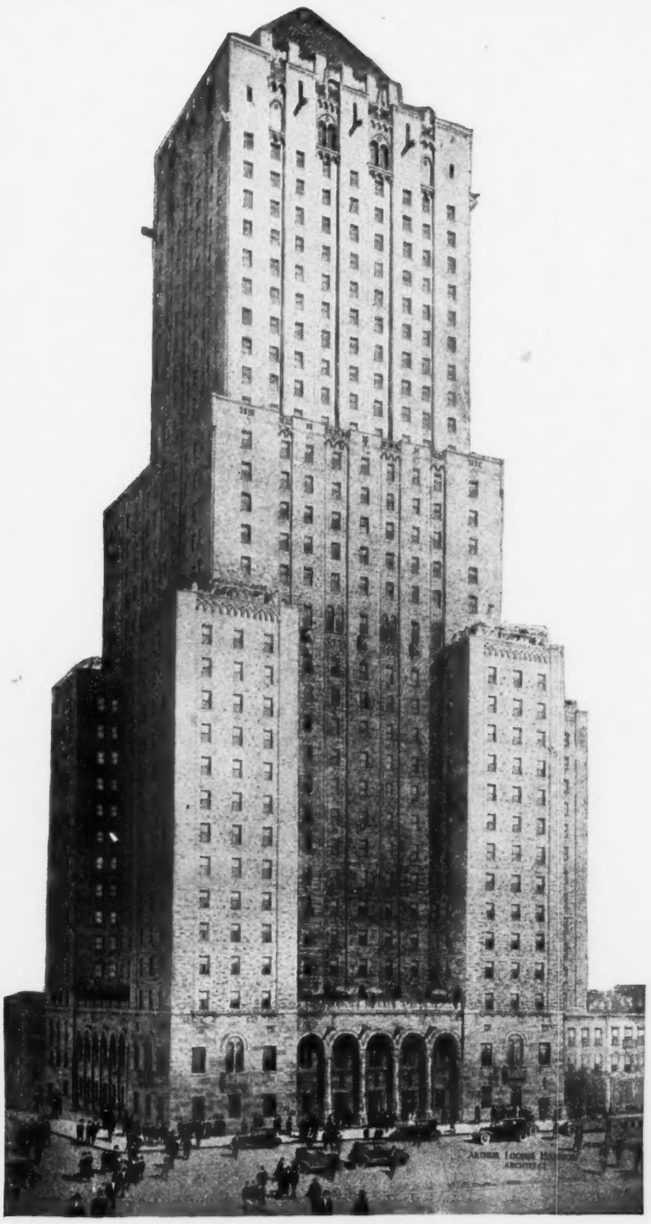
PUBLICATIONS

Bulletins of General Information, Courses of Study, Summer Session, Advanced Study and Research; and the Report of the President and the Treasurer.

Any of the above-named publications will be mailed free on application.

For information, address

ADMISSIONS OFFICE
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE 39, MASS.



Arthur Loomis Harmon, *Architect*
Jaros & Baum, *Engineers*
Gillis & Geoghegan, *Contractors*

THE SHELTON HOTEL CLUB

is Sturtevant heated and ventilated. The apparatus includes sixteen Multivane Fans and 2268 square feet of heating surface. The fans provide constant air change, to every nook and corner of building, by delivering 202,700 cubic feet of fresh air per minute.

Sturtevant engineers worked in close coöperation with those who created and built this beautiful structure. Counsel from these engineers has been present on hundreds of other similar undertakings. Consequently many architects and engineers know the benefits accruing from such contact. It is a tangible factor always at your command.

B. F. STURTEVANT COMPANY, HYDE PARK, BOSTON, MASS.

Sales Engineering Offices:

Atlanta, Ga.
Boston, Mass.
Buffalo, N. Y.
Camden, N. J.
Chicago, Ill.
Cincinnati, Ohio
Cleveland, Ohio
Dallas, Texas
Detroit, Mich.
Hartford, Conn.
Indianapolis, Ind.
Los Angeles, Cal.
Minneapolis, Minn.

Plants Located in

Hyde Park, Mass.
Sturtevant, Wis.
Berkeley, Cal.
Framingham, Mass.
Camden, N. J.
Galt, Ontario

Sturtevant
PUTS AIR TO WORK

Sales Engineering Offices:

Montreal, P. Q.
New York, N. Y.
Pittsburgh, Pa.
Portland, Ore.
Rochester, N. Y.
St. Louis, Mo.
Salt Lake City, Utah
San Francisco, Cal.
Seattle, Wash.
Springfield, Mass.
Toronto, Ont.
Washington, D. C.

BENJAMIN FRANKLIN
1706-1790
Printer, journalist, diplomat, inventor, statesman, philosopher, wit. One of the authors of the Declaration of Independence and the Constitution, author of Poor Richard's Almanack; and one of the most eminent natural philosophers of his time.

But nobody had thought to do it

By bringing electricity down from the clouds over a kite string, it was a simple thing to prove that lightning was nothing more than a tremendous electrical flash.

For centuries before Franklin flew his kite in 1751 philosophers had been speculating about the nature of lightning. With electrified globes and charged bottles, others had evolved the theory that the puny sparks of the laboratory and the stupendous phenomenon of the heavens were related; but Franklin substituted fact for theory — by scientific experiment.

Roaring electrical discharges, man-made lightning as deadly as that from the clouds, are now produced by scientists in the Research Laboratories of the General Electric Company. They are part of experiments which are making it possible to use the power of mountain torrents farther and farther from the great industrial centers.

Electrical machines bearing the mark of the General Electric Company, in use throughout the world, are raising standards of living by doing the work of millions of men.

GENERAL ELECTRIC

TECHNOLOGY PRESS, CAMBRIDGE, MASS.